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Three Essays on Hedge Fund Fee Contracts, Managerial Incentives and Risk Taking Behaviors

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THREE ESSAYS ON HEDGE FUND FEE CONTRACTS, MANAGERIAL INCENTIVES AND RISK TAKING BEHAVIORS

A Dissertation Presented

by

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DEDICATION

To my loving, supportive and inspiring parents,

Shihong Xie and Jie Zhan.

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ABSTRACT

THREE ESSAYS ON HEDGE FUND FEE CONTRACTS, MANAGERIAL INCENTIVES AND RISK TAKING BEHAVIORS

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Under the principal-agent framework, the first essay studies and compares different compensation schemes commonly adopted by hedge fund and mutual fund managers. We find that the option-like performance fee structure prevalent among hedge funds is suboptimal to the symmetric performance fee structure. However, the use of high water mark (HWM) mitigates the suboptimality, though to a very limited extent. Both our theoretical models and simulation results show that HWM will induce more managerial efforts only when a fund is slightly under the water but it will unfavorably dampen incentives when a fund is too deep under the water and when the manager's skill is poor. Allowing managers to invest personal wealth in their own funds, however, helps align interests and provides positive managerial incentives.

Existing literature has detected a ”tournament behavior” among mutual fund managers that mid-year underperformers tend to take relatively higher risk than peers in the second half-year. The second essay reexamines this issue and provides empirical evidence that such behavior does not exist among hedge fund managers, either at fund level or risk style level. Instead, hedge fund managers shift risk at mid-year in response to the moneyness of their incentive contracts.

Also, risk shifting decisions are more driven by underperformance than by outperformance. High Water Mark can strongly rein in excess risk-taking and therefore better aligns interests. Last, risk shifting on average does not improve either performance, moneyness of incentive contracts, or cash inflows.

The third essay uses factor models and optimal changepoint regression models to capture the intra-year risk dynamics of hedge fund managers. Those risk shifting managers are further divided into Informed', 'Uninformed' and 'Misinformed' groups, according to their post-shifting risk adjusted performance. We find evidence that supports the existence of an 'Adverse Selection' problem of managers compensation schemes. Namely, incentive contracts, designed to share risks and align interests, induce the strongest risk taking from the least informed or skilled hedge fund managers, whose risk-shifting decisions result in undesired or even deteriorated risk-adjusted returns for investors. We also find that the High Water Mark has only limited influence on mitigating excessive risk shifting.

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MANAGER FEE CONTRACTS AND MANAGERIAL INCENTIVES

1.1 Introduction and Literature Review

Mutual funds and hedge funds are very distinct investment vehicles that differ in many ways such as the degree of regulatory oversight, the characteristics of the typical investors, leverage and derivatives usage, and investment strategies employed, etc. At the heart of these differences is the compensation structure for asset managers of each industry. A typical hedge fund fee structure usually features an asset-based and flat-rate management fee plus a performance-based and option-like incentive fee, possibly coupled with a loss carry-forward provision known as high water mark (HWM). By contrast, most mutual fund managers are compensated by an asset-based fee, possibly plus some other fees not based on performance, such as sale charges, redemption fees, and distribution fees. Only a very small portion of mutual funds feature an incentive fee[1]. This fee, also known as a "fulcrum fee", however, unlike the form of incentive fees employed by hedge funds and most private partnerships, must be exercised symmetrically by law[2].

[1] Elton, Gruber and Blake (2003) find that in 1999, only 108 out of a total 6,716 bond and stock mutual funds used incentive fees.

[2] The specifications of the fulcrum fee were firstly enacted in a 1970 amendment to the Investment Company Act of 1940. According to the amendment, the incentive fee must be centered around an benchmark index. Any increases in fees for performance above that index must be matched by decreases in fees for performance below the index.

Fund managers' compensation schemes have long been of special interests to both academics and practitioners. In their seminal work, Ackermann, McEnally and Ravenscraft (1999) point out that

"Four basic mechanisms mitigate principal-agent problems (between investors and fund managers): incentive contracts, ownership structure, market forces, and government regulation. Hedge funds generally emphasize the first two solutions. In contrast, mutual funds tend to rely more heavily on the latter two."

In addition, they find a strong association between incentive fees and the Sharpe ratio. Liang (1999) conducts a similar cross-sectional analysis of performance with respect to incentive fees and management fees. He finds a significantly relation between performance and incentive fee but management fee is not significantly related to performance. **?** find superior performance for hedge funds with a fixed percentage and bonus-based incentive structure.

We compare a flat-fee contract and an incentive contract in Model I and II. We conclude that the optimality of each form of contracts depends heavily on the informational setting in consideration.

Although performance-based compensation schemes have become quite popular in recent years, there is considerable debate among academics over whether the symmetric incentive fee required by the SEC is in fact economically justified based on modern financial economics, especially when compared to the option-like incentive fee prevailing in hedge fund industry. For example, Starks (1987) studies two types of incentive contracts for mutual fund managers and shows that the 'symmetric" contract dominates the 'bonus' contract in aligning the manager's interests with those of the investors since the former will motivate the manager to select the investor's desired risk level and the latter tends to induce extra risk taking. Golec (1992) also applies a principal-agent model to mutual fund management and finds that incentive contracts impact both return and risk through information production. Elton, Gruber and Blake (2003), however, take the view that mutual fund's fulcrum fees with limits can always be converted to an equivalent never-negative incentive fee. As a result, differences between a symmetric and an asymmetric incentive fee are not large.

We discuss the asymmetry of incentive contacts in Model III and find that option-like bonus plan is inferior to a symmetric incentive plan since the former induces less effort than the latter.

As Ackermann, McEnally and Ravenscraft (1999) suggest, ownership structure also matters in aligning managers' interests with those of investors. Carpenter (2000) finds that the option compensation for a fund manager does not strictly lead to greater risk seeking behavior. If he trades his own account, then the manager's optimal volatility is less. Kouwenberg and Ziemba (2007) shows that risk taking is greatly reduced if a substantial amount of the manager's own money (at least 30%) is in the fund as well.

We investigate management wealth in Model IV and conclude that personal capital is an effective tool in enhancing managerial effort.

An extended body of academic research has shown concerns about that managers tend to be tempted to take excess risk when compensated by the option-like incentive plan, and discusses how the use of HWM, a loss recovery provision by many hedge funds, may limit the problem of excess risk taking behaviors by fund managers. Goetzmann, Ingersoll and Ross (2003) propose a theoretical model to evaluate the cost of the HWM provision to managers and compute the alpha-generation skill necessary to justify a fund manager's compensation. Hodder and Jackwerth (2007) use a mutli-year evaluation to show that manager's risk taking is more diverse than can be generated by existing one-period models. Panageas and Westerfield (2009) point out that in order to maintain the continuation value of option-like incentive contracts, managers do not increase risk indefinitely due to infinite horizions. Aragon and Qian (2007) study HWM in an informational setting where the manager quality is unknown to investors. They find that funds imposing liquidity constraints are more likely to have HWMs to reduce risk of investor-driven liquidation.

We study the combined usage of an option-like incentive contract and HWM in Model

V and emphasize the dual effects of incentive that HWM may give rise to. However, our study focuses on the induction of managerial effort rather than the impact on risk-taking and we show that HWM can sometimes surprisingly hurt effort.

Our paper contributes to hedge fund literature in two ways. Firstly, we theoretically and numerically exhibit how the distribution rule and the risk sharing rule embedded in a compensation scheme may impact managerial effort in the long run. Among the many findings is that HWM does not always foster effort. It can also harm incentive and therefore it could be in the investor's interest to reset HWM after a period of poor performance.

Secondly, we find that no contractual factor has a dominating role in motivating managerial effort. Each factor's impact is highly conditional on other factors as well as informational setting, fund characteristics and manager characteristics. Also, each factor may have very distinct implications for managers and investors.

The remainder of this paper is organized as the following. In Section 2, we present our single-period model and compare five different compensation contracts under different informational settings. In Section 3, we demonstrate our findings in single-period models by numerical results. In Section 4, we expand our single-period models to a multi-period horizon. In Section 5, we use simulation to illustrate induced managerial effort when we have multi-year horizons and finally Section 6 concludes.

1.2 A Single-Period Model

In a single-period framework, we study a standard principal-agent model between a representative investor (the principal) and a fund manager (the agent), employing a similar problem formation from Ross (1973) and Holmstrom (1979). Our focus is on how a specific compensation scheme affects a manager's incentive for making efforts.

Without losing generality, we consider a representative investor who owns a hedge fund firm[3], with initial investment I. The firm employs an asset manager and the man-

[3]This assumption is loosened in Model IV, in which the manager also has her stake invested in the hedge

ager chooses an effort level $e \in [0, \infty)$ at the beginning of each period. Effort e costs the manager $c(e)$. We further assume $c(\cdot)$ is twice continuously differentiable, with $c' > 0$ and $c'' > 0$. The interpretation is that e is a productive input with direct disutility for the manager and this creates an inherent difference in objectives between the principal and the agent. It is convenient to think of e as managerial actions, e.g. employing advanced technology to monitor the market and adjust portfolios accordingly, conducting innovative research in proprietary trading strategies, doing due diligence on target products, companies or markets, building up and maintaining networks to gather market information, and etc. The manager's utility is thus defined over both wealth and effort, which utility is also known as additively separable: The net utility of a manager who chooses effort level e and has terminal wealth w is expressed by $U(w, e) = u(w) - c(e)$. The manager is risk-averse over her total wealth w[4], with utility function $u(w)$. We assume $u(w)$ is twice continuously differentiable, with $u' > 0$ and $u'' < 0$. The investor's utility function $G = g(w)$ is defined over wealth alone and she may or may not be risk-neutral, i.e., $g'' \leq 0$.

Together with a random state of nature θ, the effort level e determines a monetary outcome and thus an end-of-period return r, measured in percentage, on the investor's principal I. In the same spirit of Mirrlees (1976), we suppress θ and view r as a random variable with a distribution $F(r, e)$, parameterized by manger's effort. Hence we formulate the effort-production relationship $r = r(e, \theta)$ by $F(r, e)$ in general. It is assumed that both parties agree on the probability distribution of θ and that the agent chooses e before θ is known. It is easy to see that $r_e \geq 0$ implies $F_e(r, e) \leq 0$, so that a change in e has a nontrivial effort on the distribution of r[5]. In particular, an increase in e will shift the distribution of r to the right in the sense of first-order stochastic dominance. Among many possible distributions of F that describe the effort-production relationship and meanwhile have the properties stated above, we specifically assume the following distribution throughout this

fund.

[4]The manager is assumed to be risk-averse since the problem of moral hazard can be avoided when the agent is risk-neutral, (Harris and Raviv (1979)).

[5]It will be assumed that for every e, $F_e(r, e) < 0$ at least for some r-values.

paper,

$$r = x(e) + \varepsilon \tag{1.1}$$

Where $x(\cdot)$ describes the impact of managerial effort on returns, with $x' \geq 0$. ε is a normally distributed random variable with zero mean and variance σ^2. This specification implies that an asset manager can improve the mean value of returns, or long-term performance by exerting more costly effort through $x(e)$. However, the realization of r is also subject to randomness or risk that the fund is exposed to through ε [6].Assume $f(r|e)$ is the probability density function of realized return conditional on manager's effort. After r is realized, the dollar return Ir, is then divided between the investor and the manager according to a compensation scheme s[7] designed for the manager[8]. Therefore, the investor's income will be $Ir - s$.Given the setting above, a typical principal-agent problem between an investor and a fund manager could be depicted by the following optimization problem.

The investor maximizes the expected utility of her net income by choosing a compensation scheme s for the manager and also a desired effort level e to induce from the manager at the beginning of the period,

$$\max_{e,s} E[G(w)] = \int g(Ir - s)dF(r|e) \tag{1.2}$$

subject to

1. Manager's participation constraint

$$g(s - c(e)) \geq \bar{u}_0 \tag{1.3}$$

[6] In practice, a hedge fund manager has a lot more discretion in adjusting her risk exposure than a mutual fund manager since the former has much more access to the usage of derivatives and leverage than the latter.

[7] Depending on different information settings, s could be either a function of effort e or an output indicator r.

[8] Admittedly in practice, it is usually the manager who proposes a compensation scheme for potential investors to contract upon. However, it is not of so much importance as to who designs the scheme, and we are more interested in how a specific compensation structure induces managerial effort.

where $\bar{u}_0$ is the manager's reservation (or best alternative) utility level.This constraint guarantees the agent a minimum utility.

2. Manager's incentive compatibility constraint

$$e \in \arg\max_{e} E[U(w,e)] = \int u(s)dF(r|e) - c(e) \tag{1.4}$$

This constraint guarantees that the manager finds it optimal to exert the investor's desired level of effort. This constraint plays a central role in almost all principal-agent relationships since there will be conflict of interests if this constraint is not satisfied.

1.2.1 Model I–A Fixed Fee Contract under Symmetric Information

We start from discussing an optimal compensation structure under symmetric information. Suppose that the investor can directly observe the manager's effort so that the manager cannot take any private action in her management. Since effort is observable, its level can be made part of the contract, and the manager can propose a 'take it or leave it' contract upon the observed effort level. The optimization problem that the investor has is thus,

$$\max_{e,s(e)} E[G(w)] = \int g(Ir - s(e))dF(r|e) \tag{1.5}$$

subject to

1.

$$g(s(e) - c(e)) \geq \bar{u}_0 \tag{1.6}$$

2.

$$e \in \arg\max_{e} E[U(w,e)] = \int u(s(e))dF(r|e) - c(e) \tag{1.7}$$

One possible optimal contract is,

$$s(x(e)) = \begin{cases} f(\bar{u}_0 + c(e)), & \text{if } e = e^* \\ 0, & \text{if } e \neq e^* \end{cases} \tag{1.8}$$

Where $f = u^{-1}$ is the inverse function of u. e^* is the target effort level which solutes the investor's maximization problem (2.2). This contract is optimal because it maximizes the utility of both the investor and the manager[9]. Furthermore, the contract is efficient because there is no way to make either party better off without harming the other. It is worth noting that e^* is solved without the incentive compatibility constraint and we refer to as the first-best efficient level of effort, which entails the optimal risk sharing.

The contract in Model I implies a flat-rate fee for the manager and the result above sheds lights on explaining the prevailing fee structure in the mutual fund industry. The model shows that when effort is much observable, it is possible for an investor to induce the first-best effort level from the manager by providing her with a compensation scheme not directly associated with performance. In practice, all US mutual funds must register with the SEC and send audited financial reports to the SEC on a quarterly basis. They are required to value their portfolios and price their securities daily based on market quotations that are readily available at market value or fair value. Moreover, mutual funds are required by law to allow shareholders to redeem their shares on a daily basis, in addition to providing investors with timely information regarding the value of their investments. This transparency and existing mechanism for investors, though probably not in the favor of mutual fund managers, makes it easy for investors to observe managers' effort.

[9] It is also optimal for the manager because if on one hand, she chooses e^*, then her utility will be $u(s(x(e^*))) - c(e^*) = u_0$. If on the other hand, she shirks from e^*, then her payoff will be $0 - c(e) = -c(e) \leq 0$

1.2.2 Model II-A Linear Contract (When Incentive Fee is Symmetric) under Asymmetric Information

Unlike mutual fund managers, most hedge fund managers charge a performance fee on top of a management fee. By the principal-agent theory, this fee structure is mainly due to the existence of asymmetric information between the investor and the manager rising from the fact that hedge funds are subject to very limited government oversight and disclosure requirement. Since the investor cannot largely observe a hedge fund manager's action, e.g. portfolio holdings, trading strategies, and expenses, etc, she needs to render a portion of output to the manager and provide the manager with a performance-based compensation scheme in order to share risk[10] and align interests[11]. That is, under asymmetric information, the compensation scheme s cannot be a function of effort e, but of the output r. It is, therefore, of interest to investigate how a performance-based incentive contract may help the investor to induce managerial effort[12].

There are mainly two types of incentive fees observed in the asset investment industry, namely, the symmetric incentive fee (or the fulcrum fee required for U.S mutual funds) and the asymmetric incentive fee (or the bonus plan adopted by most hedge funds). We discuss the former in Model II and the latter in Model III.

A symmetric incentive fee scheme for a manager can be described by,

$$s(r) = \alpha I + \beta I r \tag{1.9}$$

where α and β, both positive and measured in percentage, are management fee and performance fee, respectively. This compensation scheme is symmetric in the sense that

[10] Note that in Model I where there is asymmetric information, the investor is the residual claimant of output and therefore bears all production risk in the principal-agent relationship.

[11] With some sufficient conditions satisfied (see Rogerson (1985)), the theory of contracts states a very important feature of the optimal contract: the optimal compensation with unobservable effort is a random variable, rather than a fixed amount.

[12] Holmstrom (1979) proves that the principal would like to see the agent increase her effort given the performance-based sharing rule.

on one hand, if the end-of-period return is larger than zero, then the manager is awarded by receiving a proportion of the return on top of the management fee; on the other hand, if the end-of-period return is less than zero, then the manager is penalized by receiving a total compensation less than the management fee, since the second term on the right-hand side in this case is negative.

We solve the investor's expected utility maximization problem again with the incentive compatibility constraint (2.4) binding. This constraint implies that for a given linear contract $s(r)$, the manager chooses an effort level e to maximize her expected utility. Mathematically,

$$\begin{aligned} \max_e E[U(s(r),e)] &= \int u(s(r))dF(r|e) - c(e) \\ &= \int u(\alpha I + \beta I r) f(r|e) dr - c(e) \end{aligned} \tag{1.10}$$

The First Order Condition (FOC) is then

$$\frac{\partial E[U]}{\partial e} = \int u(\alpha I + \beta I r) f_e(r|e) dr - c'(e) = 0 \tag{1.11}$$

The optimal effort e^{**} induced by the symmetric incentive contract solves the above FOC. That is,

$$\int u(\alpha I + \beta I r) f_e(r|e^{**}) dr = c'(e^{**}) \tag{1.12}$$

In order to compare the induced optimal effort level to that in Model I, we assume that both the investor (principal) and the manager(agent) have a CARA utility function with different risk aversion parameters $\lambda_p \geq 0$ and $\lambda_a > 0$, respectively.

$$g(w) = -e^{-\lambda_p w} \tag{1.13}$$

$$u(w) = -e^{-\lambda_a w} \tag{1.14}$$

According to Appendix A.1, the optimal effort level e^* in Model 1 satisfies,

$$c'(e^*) = \lambda_a I(\bar{u}_0 + c(e^*))x'(e^*) \tag{1.15}$$

According to Appendix A.2, the optimal effort level e^{**} in Model 2 satisfies,

$$c'(e^{**}) = \lambda_a \beta I \exp(-\lambda_a \alpha I - \lambda_a \beta I x(e^{**}) + \frac{\lambda_a^2 \beta^2 I^2 \sigma^2}{2})x'(e^{**}) \tag{1.16}$$

Notice that the left-hand side of both equations is the same marginal cost function for the manager, and the right-hand side is the marginal profit function. Although it is difficult to obtain the closed-form expression for e^* and e^{**}, it is still possible to compare these two effort levels induced by different compensation schemes. We next discuss the scenarios in which one effort level is higher than the other by comparing the coefficient of $x'(e)$ in the two marginal profit functions. We find that σ_0^2 as follows equates the two marginal profit functions,

$$\sigma_0^2 = \frac{2(ln(\frac{\bar{u}_0 + c}{\beta}) + \lambda_a \alpha I + \lambda_a \beta I x)}{\lambda_a^2 \beta^2 I^2} \tag{1.17}$$

When $\sigma^2 > \sigma_0^2$, the marginal profit function of Model II is larger than that of Model I. As a result, e^{**} is larger than e^* and vice versa. Graphically, when σ^2 is high enough, the intersection of Marginal Cost(MC) and Marginal Profit(MP) in Model II is to the right of that in Model I and therefore a linear contract induces more effort than a fixed fee contract does.

This comparison sheds some light on the rationale behind the use of fixed fee contracts and linear contracts (symmetric incentive fees) by mutual funds. Our models have shown that when there is much uncertainty embedded in the effort-production relationship (reflected by a large σ^2), the principal may find it more optimal to associate agent's compensation s to the output r than providing a fixed fee contact $s(e)$, since the former can solicit more managerial effort e and enhance the long-term performance through $E[r] = x(e)$ in repeated contracts. Put in another way, a linear contract is a useful tool for the investor to share risk and align interests when she believes that the forthcoming production process will be very volatile.

The above discussion is consistent with the empirical results in Elton, Gruber and Blake (2003). They find that the 108 mutual funds with incentive fees, which amounts to 1.7% of the total number of mutual fund family in their sample, do exhibit (1) higher risk, (2) better risk-adjusted long-term performance, and (3) greater stock picking ability, which can be seen as a good proxy for managerial effort. Yet the authors conclude that the main driving force for the greater risk-taking behavior is the incentive fee, we add that the projected risk of a fund's future performance is in turn a key determinant of the compensation scheme designed for the fund manager. Specifically, if a fund manager is believed to take high-risk trading strategies or to hold very risky assets, then it is optimal for the investor to use incentive contracts to align interests and solicit effort. A weak support can be also drawn from Elton, Gruber and Blake (2003), in which the authors find that no money-market mutual fund uses incentive contracts. Starks (1987) also finds that low-beta mutual funds do not use incentive fees.

1.2.3 Model III-An Option-like Contract (When Incentive Fee is Asymmetric) under Asymmetric Information

Symmetric incentive contracts, however, are not embraced by the hedge fund industry since they imply a severe penalty for the manager when her performance is poor. Instead, almost all hedge funds feature an asymmetric (or option-like) incentive fee structure. The most popular one is "2% and 20%", a 2% flat management fee and a 20% incentive fee.

This incentive fee in reality awards hedge fund managers with 20% of positive return [13] and exerts no penalty even if the return is negative. We next examine whether or not this option-like contract induces more managerial effort and thus better long-term performance than a linear contract.

Suppose now the investor offers the manager an option-like compensation scheme $s(r)$ that is nonlinear in the realized output r as follows,

$$s(r) = \begin{cases} \alpha I + \beta I r, & \text{for } r \geq 0 \\ \alpha I, & \text{for } r < 0 \end{cases} \tag{1.18}$$

Accordingly, the manager's incentive problem becomes,

$$\begin{aligned} \max_{e} E[U(s(r), e)] &= \int u(s(r)) dF(r|e) - c(e) \\ &= \int u(\alpha I + \beta I r \cdot \mathbf{1}_{\{r \geq 0\}}) f(r|e) dr - c(e) \end{aligned} \tag{1.19}$$

$$s(r) = \begin{cases} \alpha I + \beta I r, & \text{for } r \geq 0 \\ \alpha I, & \text{for } r < 0 \end{cases} \tag{1.20}$$

where $\mathbf{1}_{\{r \geq 0\}} = \begin{cases} 1, & \text{for } r \geq 0 \\ 0, & \text{otherwise} \end{cases}$ is an indicator function of r.

FOC

[13] Assume there is no HWM provision.

$$
\begin{aligned}
\frac{\partial E[U]}{\partial e} &= \int_{-\infty}^{\infty} u(\alpha I + \beta I r \cdot \mathbf{1}_{\{r \geq 0\}}) f_e(r|e) dr - c'(e) \\
&= \int_{-\infty}^{0} u(\alpha I) f_e(r|e) dr + \int_{0}^{\infty} u(\alpha I + \beta I r) f_e(r|e) dr - c'(e) \\
&= \int_{-\infty}^{\infty} u(\alpha I + \beta I r) f_e(r|e) dr + \int_{-\infty}^{0} [u(\alpha I) - u(\alpha I + \beta I r)] f_e(r|e) dr \\
&- c'(e) \\
&= 0 \qquad (1.21)
\end{aligned}
$$

The optimal effort e^{***} equates the MP and MC in FOC.

$$
\int_{-\infty}^{\infty} u(\alpha I + \beta I r) f_e(r|e^{***}) dr + \int_{-\infty}^{0} [u(\alpha I) - u(\alpha I + \beta I r)] f_e(r|e^{***}) dr = c'(e^{***}) \quad (1.22)
$$

Comparing (1.22) to Model II's FOC in (1.12), we see that the only difference is the second term on the LFS of the above equation. According to Appendix A.3,

$$
\int_{-\infty}^{0} [u(\alpha I) - u(\alpha I + \beta I r)] f_e(r|e^{***}) dr < 0 \quad (1.23)
$$

It then follows that for a given effort level, the MP for manager in Model III, where the incentive is asymmetric, is less than that in Model II, where the incentive is symmetric. As a result, the optimal effort level, which is the intersection of the MP and MC, is lower in Model III than in Model II. Graphically,

This finding clearly reveals the suboptmality of an asymmetric incentive contract in terms of induced managerial effort. Moreover, this result is derived without making much assumption about the manager's utility function and the final return's probability distribution. The economic explanation for this suboptimality is that the option-like incentive contract transfers the downside risk that the manager bears under a symmetric contract to the investor. The new risk sharing rule changes the subjective probability distribution about the output that the manager perceives in the manager's favor. That is, with the same level of effort spent, she in essence has a higher expected utility from compensation under an option-like incentive contract than under a linear one. Since effort is costly to the manager, she would rather exert less effort when rebalancing her MP and MC.

A similar suboptimality is also addressed by Starks (1987). She finds that compared to symmetric incentive fees, bonus fees (asymmetric) motivate managers to choose an even lower level of resource expenditure and a higher-than-optimal level of risk. Elton, Gruber and Blake (2003), however take an opposing view and state that those two types of incentive contracts are equivalent and can be converted to each other.

1.2.4 Model IV–An Option-like Contract with Management Wealth

In practice, many investment funds and limited liability partnerships that use option-like incentive contracts, such as hedge funds, CTAs, venture capitals and real estate partnerships, allow managers to invest own wealth and hold stakes in their firms. The Lipper-Tass hedge fund database reports that as to 2008, 2568 out of 9116 hedge funds (from both graveyard dataset and live fund dataset) have management wealth[14]. This ownership structure makes these managers a principal as well as an agent and therefore has nontrivial influence on the principal-agent relationship. We next examine how an asymmetric incentive contract, combined with management wealth, motivates managers to exert effort.

Assume that the proportion of management wealth to total assets under management is k. The manager's net income is thus composed of two parts, the fees collected on the principal's investment and the accrued interest (or incurred loss) on personal investment,

$$s(r) = \begin{cases} (1-k)(\alpha I + \beta I r) + kIr, & \text{for } r \geq 0 \\ (1-k)\alpha I + kIr, & \text{for } r < 0 \end{cases} \tag{1.24}$$

[14]Lipper-Tass reports a "personal capital" dummy variable.

The manager's optimization problem is,

$$\begin{aligned}
\max_e E[U(s(r),e)] &= \int u(s(r))dF(r|e) - c(e) \\
&= \int u((1-k)(\alpha I + \beta I r \cdot \mathbf{1}_{\{r\geq 0\}}) + kIr) f(r|e) dr \\
&- c(e)
\end{aligned} \tag{1.25}$$

The FOC

$$\begin{aligned}
\frac{\partial E[U]}{\partial e} &= \int_{-\infty}^{0} u((1-k)\alpha I + kIr) f_e(r|e) dr \\
&+ \int_{0}^{\infty} u((1-k)(\alpha I + \beta I r) + kIr) f_e(r|e) dr \\
&- c'(e) \\
&= 0
\end{aligned} \tag{1.26}$$

The optimal effort e^k equates the MP and MC in the FOC

$$\int_{-\infty}^{0} u((1-k)\alpha I + kIr) f_e(r|e^k) dr + \int_{0}^{\infty} u((1-k)(\alpha I + \beta I r) + kIr) f_e(r|e^k) dr = c'(e^k) \tag{1.27}$$

According to Appendix A.4, the MP of (1.27) is larger than that in (1.22). As a result, e^k is larger than e^{***}. Graphically

The economic interpretation for the increased effort level is intuitive. With her wealth invested in the fund that she manages, (1) on the downside, the manager now is subject to a proportion of production risk and thus a decreased expected utility; (2) on the upside, she can collect more fees than with no personal investment, when $r(1-\beta)-\alpha > 0$. Both effects motivate the manager to exert more effort to enhance long-term performance. In fact, the manager's investment can be seen as a form of symmetric incentive fee at k since it penalizes managers for poor performance and awards managers for positive returns. We therefore conclude that allowing management wealth can effectively mitigate the suboptimality an option-like incentive contract may bring.

1.2.5 Model V–An Option-like Contract with High Water Mark

Recent years witness a trend in which more and more hedge fund managers add a loss carry forward provision, the high water mark (HWM), to their option-like incentive contracts. A fund with HWM has to retrieve previous loss before charging incentive fees. In practice, a HWM fund keeps records of its NAV's historical high and charges incentive fees quaterly, semi-annually or yearly only if current NAV exceeds the historical record. We next propose a model to examine how such a loss carry forward provision motivates managers to employ effort.

Assume that at the beginning of each period, a fund manager evaluates the loss she needs to recover and calculates the 'required return to reach the last watermark'[15]. To illustrate, assume the previous NAV is NAV_{-1} and the historicial high is NAV^*, then the required return to reach the last watermark is $h = \frac{\max\{NAV^* - NAV_{-1}, 0\}}{NAV_{-1}}$. Apparently, $h \geq 0$. When $h = 0$, the fund's NAV is currently at historical high. It then immediately follows that $h = 0$ at the inception of a fund. The compensation scheme for the manager is thus[16],

$$s(r) = \begin{cases} \alpha I + \beta I r, & \text{for } r \geq h \\ \alpha I, & \text{for } r < h \end{cases} \tag{1.28}$$

The manager's optimization problem is then,

[15]This concept is borrowed from Chakraborty and Ray (2008)

[16]Notice that this scheme is hypothetical and rarely observed in practice. However, it serves to better explain a more realistic one addressed after.

$$
\begin{aligned}
\max_e E[U(s(r),e)] &= \int u(s(r))dF(r|e) - c(e) \\
&= \int u(\alpha I + \beta I r \cdot \mathbf{1}_{\{r \geq h\}}) f(r|e)dr - c(e)
\end{aligned} \tag{1.29}
$$

The FOC

$$
\begin{aligned}
\frac{\partial E[U]}{\partial e} &= \int_{-\infty}^{h} u(\alpha I) f_e(r|e)dr + \int_{h}^{\infty} u(\alpha I + \beta I r) f_e(r|e)dr - c'(e) \\
&= \int_{-\infty}^{\infty} u(\alpha I + \beta I r) f_e(r|e)dr - c'(e) + \int_{-\infty}^{h} [u(\alpha I) - u(\alpha I + \beta I r)] f_e(r|e)dr \\
&= \int_{-\infty}^{\infty} u(\alpha I + \beta I r) f_e(r|e)dr - c'(e) + \int_{-\infty}^{0} [u(\alpha I) - u(\alpha I + \beta I r)] f_e(r|e)dr \\
&+ \int_{0}^{h} [u(\alpha I) - u(\alpha I + \beta I r)] f_e(r|e)dr
\end{aligned} \tag{1.30}
$$

The optimal effort level e^h equates the MP and MC in the FOC,

$$
\begin{aligned}
&\int_{-\infty}^{\infty} u(\alpha I + \beta I r) f_e(r|e^h)dr + \int_{-\infty}^{0} [u(\alpha I) - u(\alpha I + \beta I r)] f_e(r|e^h)dr \\
&\qquad + \int_{0}^{h} [u(\alpha I) - u(\alpha I + \beta I r)] f_e(r|e^h)dr = c'(e^h)
\end{aligned} \tag{1.31}
$$

It is worth noting that the first two terms are the same as the case when there is no HWM. We then examine the third term so as to compare to the no HWM case. Denote the third term by A,

$$
A(h,e) = \int_{0}^{h} [u(\alpha I) - u(\alpha I + \beta I r)] f_e(r|e)dr \tag{1.32}
$$

It is easy to see that

$$A(0,e) = 0 \tag{1.33}$$

We then attempt to depict the function shape of $A(h,e)$. According to Appendix A.5, we have

$$\frac{\partial A(h,e)}{\partial e} \begin{cases} > 0, & \text{for } h < x(e) \\ = 0, & \text{for } h = x(e) \\ < 0, & \text{for } h > x(e) \end{cases} \tag{1.34}$$

Combining the results in (1.33) and (1.34), we obtain a preliminary cognition about the functional relationship between $A(h,e)$ and h. $A(h,e)$ starts at zero when $h = 0$, then it increases in h until $h = x(e)$.[17] When $h > x(e)$, $A(h,e)$ starts decreasing in h. Thus, although we do not know the concrete shape of $A(h,e)$, It is safe to point out that A is positive on the interval $(0, x(e)]$. Depending on the value of h, $A(h,e)$ takes on very distinct properties as follows,

(1) If h is very small, smaller than the mean return $x(e^{***})$ implied by the effort level e^{***} the manager finds optimal without a HWM, i.e. the required return to recover previous loss is within the scope of manager's average performance level $x(e^{***})$, then according to (1.33) and (1.34), $A > 0$. Therefore, the MP curve in (1.31) is to the right of that in (1.22) and as a result, the optimal effort level e^h is larger than e^{***}. Graphically,

(2) If h is very large and the upper bound of $x(e)$ is very small, then according to Appendix A.6, $A(h,e) < 0$. That is to say, if a manager's skill level is very low and meanwhile she is subject to huge previous loss to recover, then with HWM in her compensation contract, to the very opposite of (1), she will find it optimal to decrease the effort level for the current period. Graphically,

In reality, the compensation schemes with HWM do not usually take the form we discussed. Instead, incentive fees are charged on the increase in NAVs over historical high.

[17] Assuming $x(e) > 0$, that is, a fund manager's mean return is always positive.

That is, a more realistic incentive contract with HWM is as follows,

$$s(r) = \begin{cases} \alpha I + \beta I(r-h), & \text{for } r \geq h \\ \alpha I, & \text{for } r < h \end{cases} \tag{1.35}$$

Compared to the hypothetical contract in (1.28), the one above does not change the probability for the manager to charge incentive fees at all, however, lowering the amount of incentive fees charged by $I\beta h$ and therefore slightly decreasing the MP for the manager in (1.31). Nevertheless, we confirm that this difference does not substantially alter the shape of $A(h,e)$ and its properties that we obtain in (1.34) remain valid.

The above results in Model V can be readily related to reality since they demonstrate the following four scenarios in hedge fund management when HWM is in effect,

1. If a fund is currently a little under the water, then the manager has positive incentive to increase effort, which is in the best interest of the investor.

2. Incentive keeps going up along with the distance to the watermark, and reaches maximum when the distance exactly equals the manager's skill level $(x(e))$.

3. If the fund is deeper under the water than the manager's skill level (when $h > x(e)$), incentive to exert more effort begins to shrink but can still be positive.

4. Under certain circumstances, i.e. when the upper bound of manager's skill level $x(e)$ is too low and when the fund is too deep under the water, the incentive to increase effort disappears. Moreover, the manager now has negative incentive and decreases her effort level instead.

The above findings are in line with numerous academic articles in hedge fund literature that HWM is employed to align interestes between investors and managers by inducing managerial effort and alleviating manager's excess risk-taking behavior tempted by option-like incentive[18]. However, we are the first to point out that the HWM's function is double-fold. Although designed to solicit effort, HWM can well dampen manager's incentive to exert effort when the chance of charging incentive fees is slim and when the manager's skill level is too low to recover previous loss. Support for the above conclusion can be found in the literature of corporate finance. A number of articles document that many firms which reward managers with stock options reset the strike price after a long period of poor performance. Although the reasons behind the reset are multifold, one of them is clear, holding deep out of the money options does not motivate managers to exert effort. With HWM, a hedge fund manager's incentive compensation can be seen as a call option with the strike set to the historical high NAV. Therefore, after repeated periods of poor performance, the call option is likely to fall deep out of money and then lose the incentive for the manager. In practice, some HWM funds reset their HWMs after a long period of poor performance and some even close for new investment, which is another means to reset the strike price.

1.3 Numerical Single-Period Results

1.3.1 Parameters and Model Specification

The five theoretical models we have discussed thus far are general in forms. In order to obtain more comparable results, we need to evaluate the models with more specific functions and parameters. Similar to Chakraborty and Ray (2008), we assume that the cost function of effort is quadratic and scaled by the size of the principal, I,

$$c(e) = \frac{I}{2}e^2 \tag{1.36}$$

$x(e)$, the function that links effort with monthly returns is represented by the natural

[18]For details, please refer to Goetzmann, Ingersoll and Ross (2003) and Agarwal, Daniel and Naik (2009), etc.

logrithm of $(1+e)$, divided by 2,

$$x(e) = \frac{ln(1+e)}{2} \tag{1.37}$$

Note that $x(e) \geq 0$ for $e \geq 0$ and $x'(e) > 0$ for $e \geq 0$. The above specification for the cost function and the production function is consistent with decreasing returns to scale with respect to increased marginal effort expenditure. The manager's risk aversion λ_a is set to 1.

All free parameters are listed in Table 1.1

1.3.2 Comparison of symmetric fees and asymmetric fees

With specification of free parameters, we are able to numerically solve Model I's FOC in (1.11) and Model II's FOC in (1.21)for the induced effort level e^{**} and e^{***}, respectively. We can then in turn examine how the induced effort level affacts the average returns of a fund as well as how a fee contract distributes the realized income (or loss) between the manager and the investor. Table 1.2 reports the numerical results under different sets of parameter values and major findings are as follows,

1. Induced Effort Level

   In all cases, asymmetric fee contracts induce lower effort level and therefore lower average returns than symmetric fee contracts. This suboptimality, according to our models, is due to the fact that asymmetric fees (without HWM) expose the manager to no downside risk and therefore provide her with less incentive to input effort.

2. Effort and Risk

   With symmetric fees, the manager's induced effort level increases in σ. To the opposite, with asymmetric fees, the manager's induced effort level decreases in σ. That is, when the production process is subject to increased risk, symmetric contracts fosters effort and asymmetric contracts kill incentives. The reason is that when a risk-averse manager, who is compensated by symmetric contracts, faces greater variation in production, she will demand more risk premium and is therefore willing to enhance the expected return by exerting more effort. However, when she is compensated by asymmetric contracts, increased variation can bring her more fees on the upside and does not hurt her on the downside. Therefore, the manager will find it lucrative to withdraw costly effort and collect more fees on the increased upside fluctuation.

3. Fees and Risk

   In almost all cases, the fees collected by managers increase in σ, which means that managers are likely to have incentive to take excess risk in order to boost compensation. However, a few exceptions take place that when high-skill managers increase risk, their fees can drop in some cases (when β =10%, 20% and 30% and σ changes from 10% to 15%). It implies that high-skill managers have less incentive than low-skill managers to manipulate risk and more incentive to exert effort.

4. The Investor's Net-Fee Income

   In all cases, symmetric contracts bring the investor higher net-fee income than asymmetric contracts. Besides, symmetric contracts bring the investor more income when she undertakes more risk, while asymmetric contracts bring less, showing that symmetric contracts is a better tool to align interests than asymmetric contracts. A most dramatic comparison takes place when the manager is of low-skill ($x = 3ln(1+e)$), the incentive fee is 30% and the fund is at high production risk ($\sigma = 30\%$). With symmetric contracts, the manager can expect to gain 88.04% of her principal, while with asymmetric contracts, she on average loses 4.33% of her principal after fee[19].

5. β and Incentive

   In this paper, β refers to the 'incentive fee rate'. In Table 1.2, we see that β does

[19] In practice, admittedly, symmetric incentive fees always have a upper limit and lower limit on size. Therefore, our results about the investor's net-fee income should be rather considered as the upper bound. The difference between the two types of incentive fees in practice is thus less dramatic.

provide incentive in the sense that the average returns and the manager's income increase in β with very few exceptions. However, it is worth noting that increase in β does not necessarily lead to increase in the investor's net-fee income. To the contrary, when the manager's skill level is low and risk is high, an increase in the incentive fee rate actually incurs more loss to the investor under an asymmetric contract. The reason is that the extra effort induced by β in these cases can not compensate for the increased fee charged on the investor.

1.3.3 Impact of Management Wealth on Effort

Table 1.3 reports the numerical results of Model IV where the manager is allowed to invest personal capital in the fund she is running. Major findings are as follows,

1. Management Wealth and Incentive

   In almost all cases, the average return, the manager's income and the investor's net-fee income increase in k, the proportion of management wealth to all assets under management. As discussed in Model IV, the reason is that with own wealth invested in the fund, the manager is in fact subject to downside risk and therefore penalized for poor performance. She thus has incentive to exert more effort. Once mean returns are enhanced, both parties benifit.

2. Management Fee and the Investor's Net-Fee Income

   If we compare Panel A to Panel B, then we see that high management fees induce low managerial effort, grant the manager with high fees and leave the investor with less net-fee income. Moreover, even if the fund has a substantial portion of management wealth, the investor's expected return may still be negative.

3. Risk and Effort

   As discussed in Table 1.2, when there is no management wealth, high production risk leads to low managerial effort. However, as the manager puts personal wealth in the fund, the higher risk, the more effort she exerts. Therefore, allowing management wealth is an effective means to avoid manager's shirk of effort and extra risk taking. Actually, management wealth is similar to a symmetric incentive fee in that it exposes the manager to both upside and downside variation. Management wealth could be seen as an 'unbounded' symmetric fee.

1.3.4 Impact of HWM on Effort

Table 1.4 reports the numerical results of Model V where the manager is subject to HWM and has previous loss to recover. Major findings are as follows,

1. Distance to Watermark and Incentive

   Although HWM is designed to induce effort by linking the manager's previous performance with current compensation, as discussed in Model V, the effect is double-fold. We see clearly in Table 1.4 how the incentive changes with the distance to watermark. In Panel A where the manager is high-skill, we observe that in many cases, her effort level, reflected by the average return, increases in h. However, there are still cases, in which the effort first increases and then drops when the required return to recover previous loss is high. The deteriorated incentive is more evident in Panel B, where in all cases, effort decreases in h. These results correspond to the Model V's conclusions and confirm that HWM can align interests to a limited extent.

2. Risk, β and Effort

   Since management wealth is not considered in Model V, it is not too surprising to observe that high risk leads to low effort. Again, we see that β is a good incentive stimulator.

1.4 Extension to a Multi-period Model

We now consider a T-period extension of the models presented in Section 2. The contract between a specific investor i and her hedge fund manager lasts for T periods, $T \geq 1$. For ease of exposition, we assume that all contractual characteristics remain the same during the exsitence of a contract.[20] In such a multi-period contract, the asset level for the investor, the compensation for the manager and their determinants reveal themselves in stages:

1. Initially, the investor brings her initial investment I_0 to the hedge fund manager and if the manager provides a HWM, then the threshold h_0, for the manager to overcome for the first period in order to charge an incentive fee, is automatically set to be zero.

2. There is no renegotiation and the contract $s(r)$ or $s(e)$ remains in effect from $t = 0$ to $t = T$.

3. The periodic return r_t during $[t-1,t]$ is jointly determined by the managerial effort through $E[r_t] = x(e_t - 1)$ and a random disturbance, $\varepsilon_t - 1$, whose value will not be realized until time t. At time t, the proceed or loss is shared between the manager and the investor according the the contract $s(r)$ (or $(s(e))$). Specifically, the manager will receive $s(r)$ for compensation and the investor will be left with $I_{t-1} + I_{t-1}r_t - s(r_t)$. The investor continues to commit all her investment with no additional investment or cash withdrawal to the same hedge fund manager[21].Thus,

$$I_t = I_{t-1}(1 + r_t) - s(r_t) \tag{1.38}$$

4. If the contract features a loss carryforwards provision (HWM) then as soon as r_t is realized, the watermark, and thus the distance to the watermark, h_t can then be

[20] Schwarz (2007) finds that the fee structure of hedge funds is subject to very limited time-series variation.

[21] We do not consider walkaway options held by investors.

determined and will be used as a benchmark for the manager's performance next period through the following iterative process,

$$h_t = \begin{cases} 0, & \text{if } r_t \geq h_{t-1} \\ I_{t-1}(h_{t-1} - r_t)/I_t), & \text{if } r_t < h_{t-1} \end{cases} \tag{1.39}$$

5. Neither the investor nor the manager has a saving option and thus they will only consume all wealth at the end of employment. However, the manager has T choices of effort to make for production at time t, $0 \leq t \leq T-1$, in order to maximize her expected utility for the rest $T-t$ periods. Her optimization problem is thus,

$$U(h_0) = \max_{\{e_t\}_0^{T-1}} \sum_{t=1}^{T} \gamma^t \Big(\int u(s(r_t, h_{t-1})) dF(r_t|e_t) - c(e_t) \Big) \tag{1.40}$$

   For convenience of notation, we assume that the discount rate $\gamma = 1$.

For Model I to IV, the solution to the multi-period model is identical to that to the single-period version, since there is no intemporal interaction involved. A manager maximizes her overall expected utility by maximizing the expected utility during each period without the consideration for future. However, there is strong interation between periods for Model V where the HWM is featured. The unrecovered loss is carried forward to future as reflected by (1.39) and enters the manager's maximization problem. Theoretically, this dynamic programming problem can be solved through the following Bellman equation,

$$V(h_t) = \max_{e_{t+1}} \Big(\int u(s(r_{t+1}, h_t)) dF(r_{t+1}|e_{t+1}) - c(e_{t+1}) + \gamma V(h_{t+1}) \Big), \forall t \leq T-1 \tag{1.41}$$

We do not, however, provide the solution to the Bellman function because it is too involved and dependent on the the specification of $x(e)$ and $c(e)$. Nevertheless, in next section we use simulation results to examine the relation between incentive contracts and managerial effort with a multi-period horizon.

1.5 Simulated Multi-Period Results

In a single-period framework, we find that HWM can either motivate or discourage effort, depending on the distance to the watermark. It is also of interest to examine how HWM will affect a fund's return, a manager's compensation and an investor's income over a multi-year horizon. Since the use of HWM makes the compensation scheme path-dependent, we need to implement simulation to generate samples in order to make statistical inferences. The simulation process is as follows,

1. At t=0, each fund has a principal of $100 and the watermark is set to h=0.

2. A manager at the beginning of each period then determines her effort to exert based on Model V. At the end of the period, the return is realized, determined by effort and a simulated innovation. The return (or loss) is then divided between the manager and investor. If there is any loss, the distance to watermark will be calculated, otherwise, it is zero.

3. This procedure is then repeated for 5 and 10 times, representing a 5-year and a 10-year horizon.

Table 1.5 reports the simulated results. We find that over multiyear horizons, HWM funds significantly underperform No HWM funds. The reason is that once a HWM fund experiences a huge loss, the next-period managerial effort will be greatly damaged. The decreased effort will in turn lead to decreased average return next period, putting the fund even deeper in the water. That is, HWM funds are very sensitive to unexpectedly huge loss and the effort and performance is likely to deteriorate very quickly after the loss takes place.

We can also see from Table 1.5 that HWM provision sustantially reduces the manager's income since she cannot charge incentive fees before the previous loss is recovered. However, ironically, the investor does not benefit from this loss carryforward provision. On the contrary, the investor receives significantly less income with HWM. We then draw a very important lesson that HWM does not always induce effort and benefit the investor. HWM should be used with caution especially when the production risk of a fund is very high. Moreover, if a fund is too deep in the water, it is not only in the manager's interest, but also in the investor's interest to reset watermark in order to regain managerial effort.

1.6 Conclusions

Compared to other investment vehicles, the hedge fund industry features its compensation schemes with a far more diverse set of contractual factors. In this paper, we focus on incentive symmetry, management wealth, loss carryforward provision, fees and their implications on managerial effort. Basically, managerial effort is determined by the distribution rule and the risk-sharing rule. Each contractual factor speficifies one or both. However, these factors are closely integrated with each other in such a way that no factor has a dominating influence on managerial incentive. Each factor's impact is heavily dependent on other factors as well as information setting, fund characteristics (e.g. size, style, liquidity and legal strcture, etc.) and management characteristics (e.g. risk aversion, skills, cost efficiency, investment horizon and tenure length, etc.). Although we derive some necessary conditions for inducing effort, it is generally difficult to design a universally optimal contract for managers. What makes the problem even more involved is the divergence of optimality between the manager and the investor. However, the many difficulties open a door for Pareto moves. That is, it is possible for each party to design innovated contracts to enhance utility without hurting the other. There is also space for regulators to improve social welfare through the supervision on management compensation schemes.

Figure 1.1 Marginal Costs and Marginal Profits in Model II and III

Figure 1.1 depicts the marginal cost and the marginal profit functions of a hedge fund manager's effect level when she charges a symmetric incentive fee (in Model II) and an asymmetric incentive fee (in Model III), respectively. e** and e*** are the respective induced effort levels at equilibrium.

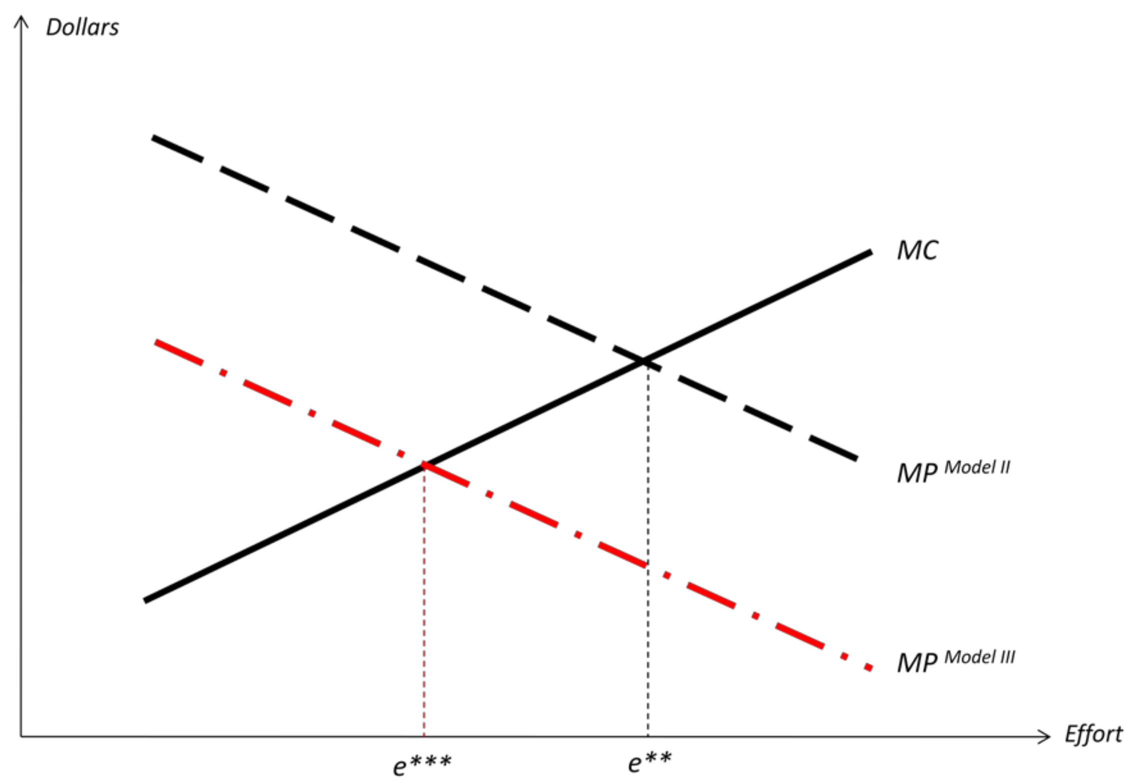


Figure 1.2 Marginal Costs and Marginal Profits in Model II, III and IV

Figure 1.2 depicts the marginal cost and the marginal profit functions of a hedge fund manager's effect level when she charges a symmetric incentive fee (in Model II) , an asymmetric incentive fee (in Model III), and an asymmetric incentive fee with her own stake invested in the fund (in Model IV), respectively. e^{**} , e^{***} and e^{k} are the respective induced effort levels at equilibrium.

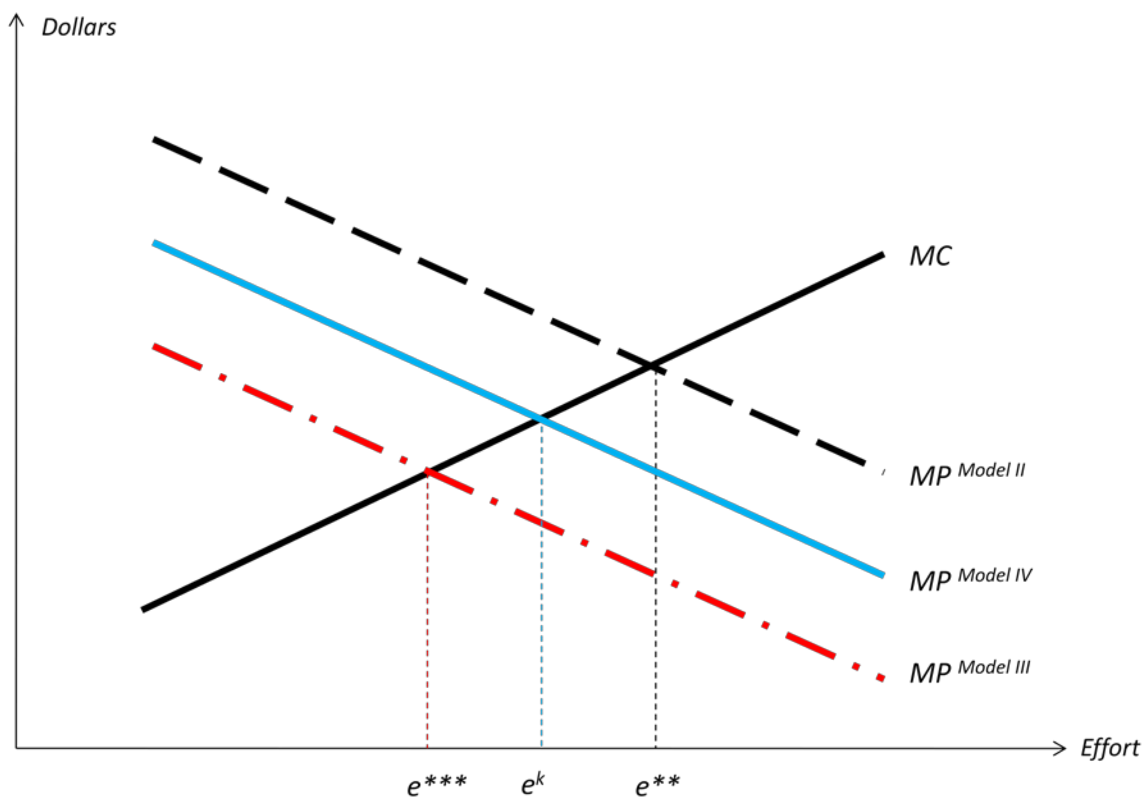


Figure 1.3 Marginal Costs and Marginal Profits in Model II, III and V (Case I)

Figure 1.3 depicts the marginal cost and the marginal profit functions of a hedge fund manager's effect level when she charges a symmetric incentive fee (in Model II) , an asymmetric incentive fee (in Model III), and an asymmetric incentive fee with HWM (in Model V), respectively. e** , e*** and e^h are the respective induced effort levels at equilibrium. Figure 1.3 represents the case in which the distance to HWM from below is relatively small.

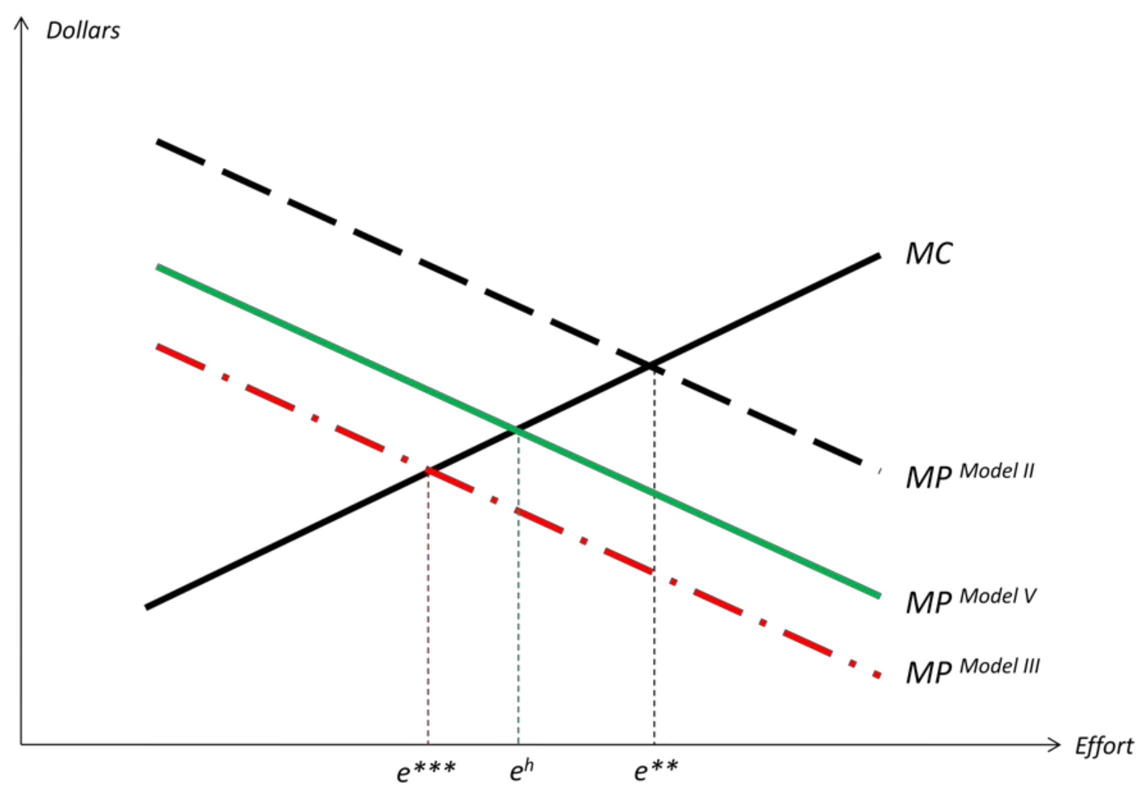


Figure 1.4 Marginal Costs and Marginal Profits in Model II, III and V (Case II)

Figure 1.4 depicts the marginal cost and the marginal profit functions of a hedge fund manager's effect level when she charges a symmetric incentive fee (in Model II) , an asymmetric incentive fee (in Model III), and an asymmetric incentive fee with HWM (in Model V), respectively. e^{**} , e^{***} and e^{h} are the respective induced effort levels at equilibrium. Figure 1.4 represents the case in which the distance to HWM from below is very large.

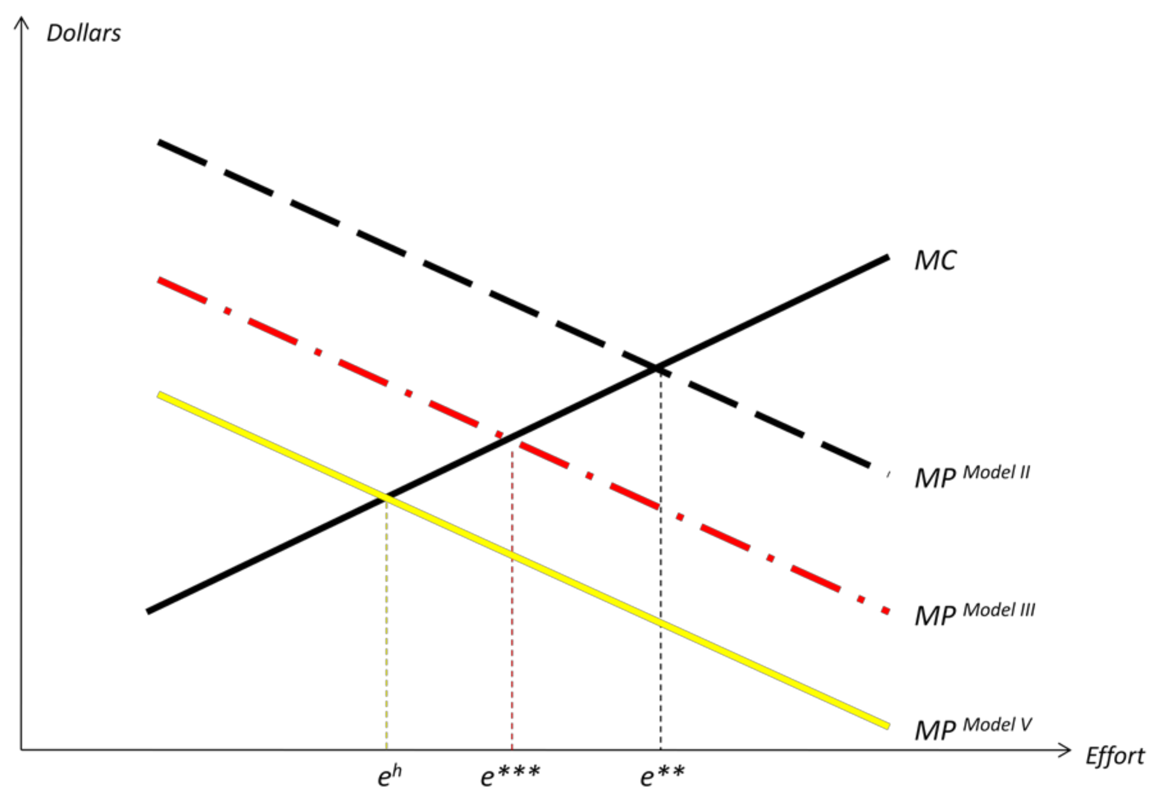


Table 1.1 Free Parameters

This table reports the free parameters and their measures employed in all five models.

Model I	**Model II**	**Model III**	**Model IV**	**Model V**
Principal *I* ($)	Principal *I* ($)	Principal *I* ($)	Principal *I* ($)	Principal *I* ($)
Manager's Risk Aversion λ_a	Manager's Risk Aversion λ_a	Manager's Risk Aversion λ_a	Manager's Risk Aversion λ_a	Manager's Risk Aversion λ_a
Management Fee α (%)	Management Fee α (%)	Management Fee α (%)	Management Fee α (%)	Management Fee α (%)
	Incentive Fee β (%)	Incentive Fee β (%)	Incentive Fee β (%)	Incentive Fee β (%)
			Management Wealth *k* (%)	
				Distance to Watermark *h* (%)

Table 1.2 Symmetric Fees vs. Asymmetric Fees

This table reports the numerical results of the comparison of symmetric fee contracts in Model II and asymmetric fee contracts in Model III. Under each set of free parameters and incentive fee type, the manager's FOC is solved and the optimal effort level for the manager e as well as the yearly average return x(e) is calculated. By integrating on all possible r, we compute the manager's net income E(s(r)), the investor's net-fee income I*(1+E(r))-E(s(r)), and total net income I*(1+E(r)). We assume throughout this table that I=\$100 and the management fee α=2%. Panel A and B represent a high-skill manager and a low-skill manager, respectively. All parameters and production functions are calibrated to annual horizon.

Panel A: x=6ln(1+e) (High-Skill)

	β=5%									β=10%							
	Avg Return(%)		ΔIncome (\$) Mgr		ΔIncome (\$) Investor		ΔIncome (\$) Total			Avg Return (%)		ΔIncome (\$) Mgr		ΔIncome (\$) Investor		ΔIncome (\$) Total	
σ	Symc	Asymc	Symc	Asymc	Symc	Asymc	Symc	Asymc	σ	Symc	Asymc	Symc	Asymc	Symc	Asymc	Symc	Asymc
10%	13.55	11.23	2.67	2.59	10.87	8.63	13.55	11.23	10%	15.84	13.06	3.58	3.35	12.26	9.71	15.84	13.06
15%	14.82	8.85	2.74	2.57	12.08	6.28	14.82	8.85	15%	19.77	10.8	3.98	3.29	15.8	7.51	19.77	10.8
20%	16.71	7.18	2.84	2.6	13.87	4.58	16.71	7.18	20%	25.74	8.67	4.57	3.31	21.16	5.37	25.74	8.68
25%	19.31	6.07	2.97	2.67	16.34	3.41	19.31	6.07	25%	34	7.15	5.4	3.4	28.6	3.75	34	7.15
30%	22.74	5.27	3.14	2.74	19.6	2.53	22.74	5.27	30%	44.73	6.06	6.47	3.52	38.26	2.53	44.73	6.06

	β=20%									β=30%							
	Avg Return(%)		ΔIncome (\$) Mgr		ΔIncome (\$) Investor		ΔIncome (\$) Total			Avg Return (%)		ΔIncome (\$) Mgr		ΔIncome (\$) Investor		ΔIncome (\$) Total	
σ	Symc	Asymc	Symc	Asymc	Symc	Asymc	Symc	Asymc	σ	Symc	Asymc	Symc	Asymc	Symc	Asymc	Symc	Asymc
10%	18.17	12.75	5.63	4.64	12.53	8.1	18.17	12.75	10%	21.26	12.26	8.38	5.84	12.88	6.42	21.25	12.26
15%	28.32	11.05	7.66	4.61	20.66	6.43	28.32	11.05	15%	37.93	10.88	13.38	5.88	24.55	5.00	37.93	10.88
20%	43.49	9.04	10.7	4.66	32.79	4.38	43.49	9.04	20%	62.32	9.01	20.7	5.98	41.62	3.02	62.32	9.00
25%	63.81	7.45	14.76	4.83	49.05	2.62	63.81	7.45	25%	94.41	7.46	30.32	6.24	64.09	1.22	94.42	7.46
30%	89.31	6.28	19.86	5.07	69.45	1.21	89.31	6.29	30%	134.16	6.24	42.25	6.60	91.91	-0.36	134.16	6.24

Table 1.2 (continued)

Panel B: x=3ln(1+e) (Low-Skill)

	β=5%									β=10%							
	Avg Return(%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total			Avg Return (%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total	
σ	Symc	Asymc	Symc	Asymc	Symc	Asymc	Symc	Asymc	σ	Symc	Asymc	Symc	Asymc	Symc	Asymc	Symc	Asymc
10%	5.19	2.4	2.26	2.27	2.93	0.14	5.19	2.41	10%	8.35	3.59	2.84	2.6	5.52	0.99	8.36	3.59
15%	5.85	1.94	2.29	2.35	3.56	-0.41	5.85	1.94	15%	11.37	2.64	3.14	2.74	8.23	-0.1	11.37	2.64
20%	6.88	1.65	2.34	2.44	4.53	-0.8	6.87	1.64	20%	16.28	2.1	3.63	2.91	12.65	-0.81	16.28	2.1
25%	8.39	1.43	2.42	2.54	5.97	-1.1	8.39	1.44	25%	23.5	1.74	4.35	3.09	19.15	-1.35	23.5	1.74
30%	10.52	1.27	2.53	2.63	7.99	-1.36	10.52	1.27	30%	33.28	1.49	5.33	3.27	27.95	-1.78	33.28	1.49

	β=20%									β=30%							
	Avg Return(%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total			Avg Return (%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total	
σ	Symc	Asymc	Symc	Asymc	Symc	Asymc	Symc	Asymc	σ	Symc	Asymc	Symc	Asymc	Symc	Asymc	Symc	Asymc
10%	12.87	4.34	4.57	3.31	8.29	1.03	12.86	4.34	10%	17.22	4.49	7.17	3.99	10.05	0.5	17.22	4.49
15%	22.37	3.03	6.47	3.52	15.89	-0.49	22.36	3.03	15%	33.48	3.12	12.04	4.3	21.44	-1.18	33.48	3.12
20%	36.98	2.32	9.4	3.84	27.59	-1.52	36.99	2.32	20%	57.52	2.37	19.26	4.77	38.27	-2.4	57.53	2.37
25%	56.84	1.88	13.37	4.19	43.47	-2.31	56.84	1.88	25%	89.27	1.91	28.78	5.29	60.49	-3.38	89.27	1.91
30%	81.88	1.58	18.38	4.55	63.5	-2.98	81.88	1.57	30%	128.64	1.49	40.59	5.82	88.04	-4.33	128.63	1.49

Table 1.3 Management Wealth and Effort

This table reports the numerical results of Model IV in which management wealth is considered. k represents the proportion of management wealth to all assets under management and k ranges from 0% to 20%. Under each set of free parameters, the manager's FOC is solved and the optimal effort level for the manager e as well as the yearly average return x(e) is then calculated. By integrating on all possible r, we compute the manager's net income E(s(r)), the investor's net-fee income I*(1+E(r))-E(s(r)), and total net income I*(1+E(r)). We assume throughout this table that I=$100 and that the effort-production function is x(e)=6ln(1+e). Panel A and B represent a low management fee and a high management fee scenario, respectively. All parameters and production functions are calibrated to annual horizon.

Panel A: α=2%																	
	β=5%									β=10%							
	Avg Return(%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total			Avg Return (%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total	
k	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	k	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%
0%	8.85	5.27	2.57	2.74	6.28	2.53	8.85	5.27	0%	10.8	6.06	3.29	3.52	7.51	2.53	10.8	6.05
5%	16.24	23.82	3.53	4.4	12.7	19.43	16.23	23.83	5%	16.14	23.76	4.34	5.69	11.8	18.06	16.14	23.75
10%	20.87	46.27	4.85	8.55	16.02	37.73	20.87	46.28	10%	20.69	46.24	5.78	10.66	14.91	35.58	20.69	46.24
15%	25.33	68.75	6.59	14.94	18.74	53.81	25.33	68.75	15%	25.22	68.74	7.65	17.86	17.57	50.88	25.22	68.74
20%	29.95	91.19	8.79	23.49	21.16	67.7	29.95	91.19	20%	29.9	91.19	9.98	27.13	19.92	64.05	29.9	91.18

	β=20%									β=30%							
	Avg Return(%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total			Avg Return (%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total	
k	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	k	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%
0%	11.05	6.29	4.61	5.07	6.44	1.21	11.05	6.28	0%	10.88	6.24	5.88	6.60	5.00	-0.36	10.88	6.24
5%	15.83	17.16	5.91	7.02	9.91	10.14	15.82	17.16	5%	15.62	23.46	7.46	10.82	8.16	12.64	15.62	23.46
10%	20.45	46.18	7.63	14.88	12.82	31.31	20.45	46.19	10%	20.31	46.13	9.48	19.08	10.83	27.04	20.31	46.12
15%	25.10	67.31	9.78	23.26	15.32	44.05	25.10	67.31	15%	25.02	68.68	11.91	29.54	13.11	39.13	25.02	68.67
20%	29.85	90.04	12.37	34.02	17.48	56.02	29.85	90.04	20%	29.81	91.18	14.75	41.72	15.06	49.46	29.81	91.18

Table 1.3(continued)

Panel B: α=5%

	β=5%							
	Avg Return(%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total	
k	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%
0%	0.37	0.25	5.31	5.60	-4.94	-5.35	0.37	0.25
5%	2.02	3.95	5.19	5.61	-3.16	-1.67	2.03	3.94
10%	6.43	25.73	5.58	8.38	0.85	17.36	6.43	25.74
15%	13.11	53.66	6.84	14.60	6.27	39.06	13.11	53.66
20%	20.12	79.98	8.85	23.20	11.27	56.79	20.12	79.99

	β=10%							
	Avg Return (%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total	
k	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%
0%	0.51	0.30	5.62	6.21	-5.12	-5.92	0.50	0.29
5%	2.09	3.96	5.53	6.28	-3.44	-2.32	2.09	3.96
10%	6.45	25.73	6.02	9.68	0.42	16.05	6.44	25.73
15%	13.10	53.66	7.46	16.90	5.64	36.76	13.10	53.66
20%	20.12	79.98	9.68	26.40	10.43	53.59	20.11	79.99

	β=20%							
	Avg Return (%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total	
k	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%
0%	0.59	0.31	6.26	7.43	-5.66	-7.11	0.60	0.32
5%	2.13	3.89	6.21	7.61	-4.07	-3.72	2.14	3.89
10%	6.45	25.73	6.90	12.29	-0.45	13.44	6.45	25.73
15%	13.09	52.83	8.71	21.24	4.38	31.60	13.09	52.84
20%	20.11	79.98	11.34	32.80	8.77	47.18	20.11	79.98

	β=30%							
	Avg Return (%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total	
k	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%
0%	0.62	0.32	6.89	8.64	-6.27	-8.32	0.62	0.32
5%	2.15	3.63	6.89	8.88	-4.74	-5.25	2.15	3.63
10%	6.45	25.62	7.78	14.86	-1.33	10.76	6.45	25.62
15%	13.08	53.66	9.95	26.09	3.13	27.56	13.08	53.65
20%	20.10	79.98	13.00	39.20	7.11	40.78	20.11	79.98

Table 1.4 HWM and Effort

This table reports the numerical results of Model IV in which management wealth is considered. h represents the required return to recover previous loss and h ranges from 0% to 8%. Under each set of free parameters, the manager's FOC is solved and the optimal effort level for the manager e as well as the yearly average return x(e) is then calculated. By integrating on all possible r, we compute the manager's net income E(s(r)), the investor's net-fee income I*(1+E(r))-E(s(r)), and total net income I*(1+E(r)). We assume throughout this table that I=$100 and the management fee α=2%. Panel A and B represent a high-skill manager and a low-skill manager, respectively. All parameters and production functions are calibrated to annual horizon. Notice that the investor's income is also net of previous loss. "n/a" appears where no positive effort will maximize the manager's objective function.

Panel A: x(e)=6ln(1+e) (High-Skill)

	β=5%									β=10%							
	Avg Return(%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total			Avg Return (%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total	
h	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	h	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%
0%	8.85	5.27	2.57	2.74	6.28	2.54	8.85	5.27	0%	10.80	6.06	3.29	3.52	7.51	2.53	10.80	6.06
2%	8.59	5.16	2.49	2.68	4.10	0.48	6.59	3.16	2%	10.93	6.01	3.15	3.41	5.78	0.60	8.93	4.01
4%	8.18	5.02	2.42	2.62	1.76	-1.60	4.18	1.02	4%	10.93	5.93	3.01	3.30	3.92	-1.37	6.93	1.93
6%	7.60	4.87	2.34	2.57	-0.74	-3.70	1.60	-1.13	6%	10.75	5.82	2.87	3.19	1.89	-3.36	4.75	-0.18
8%	6.87	4.70	2.27	2.52	-3.41	-5.82	-1.13	-3.30	8%	10.36	5.70	2.72	3.09	-0.37	-5.39	2.36	-2.30

	β=20%									β=30%							
	Avg Return(%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total			Avg Return (%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total	
h	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	h	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%
0%	11.05	6.28	4.61	5.07	6.44	1.21	11.05	6.29	0%	10.88	n/a	5.88	n/a	4.99	n/a	10.88	n/a
2%	11.45	6.29	4.37	4.85	5.08	-0.55	9.45	4.29	2%	11.36	n/a	5.54	n/a	3.82	n/a	9.36	n/a
4%	11.76	6.27	4.13	4.63	3.63	-2.36	7.76	2.27	4%	11.77	n/a	5.20	n/a	2.57	n/a	7.77	n/a
6%	11.95	6.22	3.89	4.42	2.07	-4.19	5.95	0.22	6%	12.08	n/a	4.85	n/a	1.22	n/a	6.08	n/a
8%	11.99	6.14	3.63	4.21	0.35	-6.07	3.99	-1.86	8%	12.26	n/a	4.51	n/a	-0.25	n/a	4.26	n/a

Table 1.4(continued)

Panel B: x(e)=3ln(1+e) (Low-Skill)

	β=5%									β=10%							
	Avg Return(%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total			Avg Return (%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total	
h	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	h	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%
0%	1.94	1.27	2.40	2.63	1.21	-1.36	3.61	1.27	0%	2.64	1.49	2.74	3.27	-0.10	-1.78	2.64	1.49
2%	1.80	1.23	2.33	2.58	-0.96	-3.35	1.37	-0.77	2%	2.51	1.46	2.62	3.17	-2.11	-3.71	0.51	-0.54
4%	1.64	1.19	2.28	2.53	-3.18	-5.34	-0.90	-2.81	4%	2.35	1.43	2.52	3.07	-4.17	-5.64	-1.65	-2.57
6%	1.47	1.15	2.23	2.48	-5.43	-7.33	-3.21	-4.85	6%	2.15	1.39	2.43	2.98	-6.27	-7.59	-3.85	-4.61
8%	1.30	1.10	2.18	2.44	-7.71	-9.34	-5.53	-6.90	8%	1.94	1.35	2.34	2.89	-8.41	-9.54	-6.06	-6.65

	β=20%									β=30%							
	Avg Return (%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total			Avg Return (%)		ΔIncome ($) Mgr		ΔIncome ($) Investor		ΔIncome ($) Total	
h	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	h	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%	σ=15%	σ=30%
0%	3.03	1.58	3.52	4.55	-0.49	-2.98	3.03	1.58	0%	3.12	n/a	4.30	n/a	-1.18	n/a	3.12	n/a
2%	2.96	1.56	3.30	4.35	-2.33	-4.79	0.96	-0.44	2%	3.09	n/a	3.96	n/a	-2.87	n/a	1.09	n/a
4%	2.85	1.54	3.09	4.16	-4.24	-6.62	-1.15	-2.46	4%	3.01	n/a	3.65	n/a	-4.64	n/a	-0.99	n/a
6%	2.68	1.51	2.89	3.97	-6.21	-8.46	-3.32	-4.49	6%	2.87	n/a	3.36	n/a	-6.50	n/a	-3.13	n/a
8%	2.47	1.48	2.72	3.80	-8.25	-10.32	-5.53	-6.52	8%	2.68	n/a	3.11	n/a	-8.43	n/a	-5.32	n/a

Table 1.5 HWM Vs. No HWM in the Long Run

This table reports the simulated results that compare a HWM and a No HWM fund over a multi-period horizon. The simulation is based on 1000 replications. At the beginning of each period t, the manager's FOC is solved and the optimal effort level for the manager e_t as well as the yearly average return $x(e_t)$ is then calculated. By simulating the periodic white noise of r_t, we obtain the path of realized returns and therefore the path of watermarks for each replication. Using T-tests, we compare a HWM fund to a No HWM fund in terms of fund's annual returns, manager's annual compensation and the investor's annual income. The figures in parentheses are the double-tail t statistics. We assume throughout this table that I=\$100, α=2% and β=20%. Panel A and B represent a high skill manager and a low skill manager, respectively. All parameters and production functions are calibrated to annual horizon.

Panel A: x(e)=6ln(1+e) (High-Skill)									
	Annual Return (%)			Annual Income Manager (\$)			Annual Income Investor (\$)		
	HWM	No HWM	Diff	HWM	No HWM	Diff	HWM	No HWM	Diff
5 years									
σ=10%	9.31	11.60	-2.29 (<0.01)	4.46	5.04	-0.58 (<0.01)	5.03	6.32	-1.28 (<0.01)
σ =30%	3.45	7.58	-4.13 (<0.01)	4.12	5.08	-0.95 (<0.01)	-4.37	-2.03	-2.33 (0.05)
10 years									
σ =10%	7.91	8.41	-0.49 (0.23)	4.65	4.89	-0.23 (0.10)	3.37	4.09	-0.71 (0.03)
σ =30%	4.29	8.59	-4.30 (<0.01)	4.04	5.31	-1.27 (<0.01)	-3.73	-1.03	-2.65 (0.02)

Table 1.5(continued)

Panel B: $x(e)=3\ln(1+e)$ (Low-Skill)									
	Annual Return (%)			Annual Income Manager ($)			Annual Income Investor ($)		
	HWM	No HWM	Diff	HWM	No HWM	Diff	HWM	No HWM	Diff
5 years									
σ=10%	3.39	4.75	-1.35 (<0.01)	3.04	3.42	-0.38 (<0.01)	0.09	1.07	-0.97 (<0.01)
σ =30%	0.46	3.28	-2.82 (0.04)	3.63	4.37	-0.75 (<0.01)	-7.22	-6.01	-1.21 (0.34)
10 years									
σ =10%	3.02	3.99	-0.96 (0.03)	2.91	3.34	-0.42 (<0.01)	-0.18	0.32	-0.51 (0.13)
σ =30%	1.44	4.75	-3.30 (0.01)	3.41	4.82	-1.41 (<0.01)	-6.03	-4.56	-1.47 (0.27)

CHAPTER 2

A REEXAMINATION OF HEDGE FUND TOURNAMENT AND RISK-SHIFTING BEHAVIOR

2.1 Introduction

It has been suggested by agency theory and widely addressed in finance literature that asset managers have a propensity to participate in a 'tournament game', when their compensation is associated to relative performance. For example, in their seminal work, Brown, Harlow and Starks (1996) find that during 1976 to 1991, 334 U.S growth-oriented mutual fund managers demonstrated 'tournament' behavior that mid-year underperformers took more portfolio risk than mid-year outperformers in the following six months. One refutable explanation is that the mutual fund market provides such a tournament environment that mutual fund managers with comparable investment objectives compete with one another in each assessment period (usually one calendar year) for superb performance ranking in order to attract new capital. Moreover, mutual fund investors are very responsive to these rankings (see Sirri and Tufano (1998)) in an asymmetric mode. Namely, top-ranking funds receive notably larger shares of new investment in subsequent periods, while bottom-ranking funds do not suffer from as significant capital outflows. Therefore, those tournament competitors who fall behind peers in the middle of a tournament period have strong incentives to manipulate risk in an aggressive manner, hoping for ending up as top performers in the game. By and large, a tournament setting can substantially lessen the risk aversion of underperforming players, especially when upside reward considerably outweighs downside punishment. This excessive risk-taking behavior from underperformers in a tournament has also been tested for among hedge fund managers (e.g., see Brown, Goetzmann and Park (2001), Clare and Motson (2009) and Aragon and Nanda (2009). The hedge fund industry has been increasingly drawing attentions from both practitioners and academics in the recent decade mostly because of its persistent superior performance measured by either absolute or risk-adjusted returns(e.g. see Ackermann, McEnally and Ravenscraft (1999), Brown, Goetzmann and Ibbotson (1999), Liang (1999) and Jagannathan, Malakhov and Novikov (2010)). One defining feature that distinguishes hedge fund managers from their mutual fund peers is that the former are expected and paid to deliver absolute positive returns for clients regardless adverse market conditions or investment environments, given the very light regulatory oversight they are subject to and the abundance of investment tools to actively place bets, such as derivatives, leveraging and short sales that hedge fund managers can implement at great discretion.

Besides, hedge fund and mutual fund managers have very distinct fee structures designed to align interests and to provide incentives. On one hand, mutual fund managers strive to outperform peers or investment benchmarks mandated in the prospectus in order to attract outside investors to the existing capital pool, based on which they charge management fees. On the other hand, however, hedge fund managers' compensation schemes are usually more mixed, for they are composed not only by management fees, but also by, notably, performance fees, which account for a significant portion of trading profits that exceed a preset active investment benchmark (20% in the most prevailing 2/20 hedge fund fee structure).

In view of the discrepancy in pay-performance relations resulting from different compensation schemes of hedge fund and mutual fund managers discussed above, we are then motivated to reexamine the tournament behavior among hedge fund managers with the conjecture that all hedge fund managers are not driven exclusively by relative performance ranking when producing performance and making risk decisions.

In this paper, we only find very weak evidence, in accordance with existing literature, that hedge fund managers participated in risk tournaments during 1994 to 2008. Our two novel tests at fund level and strategy level, respectively, do not detect any tournament behavior among hedge fund managers. We attribute this finding to that hedge fund managers are tied to relative ranking much less than mutual fund managers, while they have much greater economic incentives to deliver absolute returns so as to charge fees. Our results confirm that if an individual hedge fund manager's mid-year performance does not exceed a particular threshold (could be the hurdle rate, the historical high of NAV, or the combination of both), then she is likely to increase risk in the second half-year.

Second, our results demonstrate that hedge fund managers instead correspond to their absolute performance strongly by changing risk at mid-year. That is, a hedge fund manager tends to increase risk when she finds her incentive contract under the water. However, her motive to decrease risk when she has already outperformed her own investment benchmark is not as strong.

Third, we examine the functionality of High Water Mark (HWM hereafter), a loss carry forward provision that has been more and more adopted by hedge funds in recent years. Our regression results show that the HWM functions very well in restraining hedge fund managers from taking excessive risks. One explanation is that the implementation of HWM effectively extends the investment horizon (see Panageas and Westerfield (2009)) of hedge fund managers and therefore rein in their short-term risk-taking behaviors such as tournament. Last, we examine the performance and flow consequences of hedge fund managers' risk shifting. Results show that risk-shifting does not help improve either performance or subsequent flows. Therefore, such behavior destroys value. The outline of the rest of this paper is as follows. Section 2 reviews existing Literature. Section 3 describes the data and empirical models. Section 4 and 5 detail the contingency table approach and regression approach, respectively. Section 6 examines the performance and flow consequences of risk shifting. Section 7 provides robustness tests and Section 8 concludes.

2.2 Literature Review

Our paper is related to existing literature along the following dimensions.

The seminal work by Brown, Harlow and Starks (1996) find that the risk tournament is mainly driven by the relative ranking of mutual fund managers at year end. Kempf and Ruenzi (2008) reexamine this issue and provide supporting evidence. They also investigate other driving forces of tournament and find the relative position within a mutual fund family also matters. In a further study, Kempf, Ruenzi and Thiele (2009) find that the risk taking behaviors of mutual fund managers vary depending on whether the employment risk or the compensation incentives prevail in a particular year. Massa and Patgiri (2009) find evidence that high-incentive mutual fund contracts lead to higher risk taking, higher risk-adjusted performance and persistence in outperformance though they also reduce the funds' survival probability. Chevalier and Ellison (1997) lend empirical evidence to the rationale of risk tournament by finding that the convexity of the flow-performance relationship can explain the increase or decrease in the riskiness of a mutual fund. Brown, Goetzmann and Park (2001) extend the study to hedge fund industry and find that risk shifts in hedge funds and CTAs are associated with relative performance rather than absolute performance. They attribute the finding to career concerns and reputation costs. Clare and Motson (2009) address the tournament behaviors among hedge fund managers and argue that option-like incentives drive managers' risk taking. However, their study shows that the tournament behaviors are dominated by lock-in behaviors, i.e. reducing the risk of a successful fund. Aragon and Nanda (2009) investigate the same issue and conclude that tournament is prevailing mainly in the incubation period. Ackermann, McEnally and Ravenscraft (1999) provide excellent insights regarding how managerial incentives of hedge fund managers may make risk taking diverge from investors' preferred level. Kouwenberg and Ziemba (2007) study incentive fees and hedge fund risk taking. They document that the level of incentive fees is positively related to excess downside risk. Within a corporate finance framework, Coles Daniel and Naveen (2006) link higher sensitivity of CEO wealth to stock volatility to riskier policy choices, which finding helps explain the relationship between incentives and risk-taking in hedge fund industry. Unlike most existing literature, Li (2006) study hedge fund risk taking over two-year sample periods and find shifts in risk taking in response to relative performance and high-water-mark. Carpenter (2000) in a theoretical paper argues that option-like incentives do not necessarily lead to greater risk seeking. Panageas and Westerfield (2009) address that spanning a manager's investment horizon can effectively reduce her risk taking despite her risk appetite, pointing out a hopeful remedy for the excess risk taking arising from tournament behaviors. Dass, Massa and Patgiri (2008) report opposing results to the above literature that incentive fees reduce mutual fund managers' tendency to herd.

2.3 Data

2.3.1 Introduction and Summary Statistics

The hedge fund data used in our empirical studies come from the Lipper TASS hedge fund database, one of the leading hedge fund data vendors. We utilize individual hedge fund performance and characteristic data, as well as the Credit Suisse Hedge Fund Indices for 10 risk styles. Since the hedge fund industry has been historically subject to very light regulation, there are no mandatory reporting standards that hedge fund managers are required to follow. As a result, there exists a collection of well-documented hedge fund database biases that hedge fund researchers need to carefully cope with. For example, hedge fund data may contain only information for funds that are still in operation and lack the information for funds that are already out of business or close to new investments (referred to as 'survivorship bias'). Hedge fund managers may choose whether to report to data vendors and if so, which vendor(s) to report to at utter discretion (referred to as 'self-selection bias'). After they report to a database, managers can voluntarily provide the data vendor with their track records, where there is no guarantee that the reported historical performance has been audited and validated (referred to as 'back-filling bias'). For more detailed analyses of the impact of these biases, see Brown, Goetzmann and Ibbotson (1999), Fung and Hsieh (2000), Liang (2000) and Fung, Hsieh, Naik and Ramadorai (2008)

In view of this, we impose several screening criteria in selecting our sample in order to minimize the influence of potential biases.

To exclude the impact of extreme returns, we winsorize the whole data at 0.01% on both tails. To mitigate the survivorship bias, we include both the 'live funds' and 'graveyard funds' reported by TASS in our sample. Our sample only covers Jan. 1994 through Dec. 2008 because 'graveyard funds' were not recorded by Lipper TASS until 1994. Every fund in our sample must be denominated in US dollars, report monthly returns, management fees and incentive fees, and have complete return history for at least one calendar year. To minimize the backfilling bias, we purge returns of the first 12 months for each hedge fund. We also discard hedge funds whose risk strategy is labeled as Undefined, Multi-Strategy, Other and Options Strategy, for they represent too few observations [1] to generate meaningful statistic reference. These screening criteria result in a total sample of 7,206 hedge funds and 426,852 observations.

In the analyses that follow, we benchmark the risk-taking of each individual hedge fund to a hedge fund index of same risk strategy. The hedge fund indices used in this paper are Credit Suisse/Tremont Hedge Fund Indices USD of 10 risk styles with the same Lipper TASS risk strategy classification. The only exception is Fund of Hedge Funds, for which

[1] The three categories altogether represent only 77 funds and 2,761 observations.

we use TASS Fund of Funds Universe Average instead. We calculate monthly returns and mid-year risk-shifting for each index and compare them to individual hedge funds. Table 2.1 reports the summary statistics.

2.3.2 Hedge Fund Compensation Structure and Fee Incentives

In order to quantify and contrast the monetary incentives from the management fee and performance fee, we estimate and report a collection of key variables of hedge fund compensation structure in Table 2.2. On one hand, of all 7,206 hedge funds in our sample, the average reported management fee accounts for 1.49% of a hedge fund's NAV. On the other, however, hedge fund managers do not usually report collected performance fees in percentage of NAV. Therefore, we need to estimate this variable given incentive fee rates provided by Lipper TASS database and some simplifying assumptions.

The difficulty in estimating the charged performance fee is at least threefold. First, for those hedge funds that feature a HWM provision, a time series of historical high of NAVs needs to be established. Second, investors entering a fund at different time may have different HWM throughout their investment, in spite that a fund only reports one unique NAV each month. Third, many hedge funds, if not all, impose that managers have to outperform a usually passive benchmark rate, for example, the LIBOR, the one-year T-bill rate, or the S&P 500 Index, plus a spread, before collecting any performance fees. Unfortunately, Lipper TASS does not have a uniform data column for hurdle rates as of the writing of this paper [2] .

We estimate the paid-out incentive fees based on the assumption that each hedge fund has only one share class and therefore maintains only one HWM [3]. For those funds that have a HWM provision, we estimate and update the HWM at the end of each calendar year.

[2] Some hedge fund managers disclose their hurdles in the side notes they report to Lipper TASS database. Interested researchers need to hand-collect this information.

[3] There is a prevailing corrective method called the Share Equalization Method in hedge fund industry that enables a hedge fund to use only one high water mark to keep track of incentive fees of all share classes.

All calculation in Table 2.2 is based on three hypothetical hurdle rates, 0%, 4% and 8% annually, that hopefully represent the real spectrum of hurdles in the hedge fund industry [4].

A remarkable observation from Table 2.2 is that compared to the 1.49% of NAV that management fees account for on average, paid-out incentive fees historically take up no less than 2.26% of investors' asset each year. This difference is statistically and economically significant. In later sections, we are dedicated to investigating whether the monetary incentives from the combination of two fees have shaped hedge fund managers' risk-shifting behavior differently from mutual fund managers, who feed on only one flat asset-based fee.

Other evidence demonstrated in Table 2.2 includes that hedge funds on average spend a rather lengthy time under the high water during a calendar year. Therefore, whether they can beat their own benchmark (the HWM, the hurdle or the combination of the two) and savor the incentive fee shall have meaningful impact on hedge fund managers' pay-performance relation in a year. Besides, if we consider the incentive fee as a series of European call options with one year expiration granted to hedge fund managers, Table 2.2 illustrates that the options are on average at the money in mid-years, where the first derivative of option value with respect to volatility (The Greek Vega) is maximum, according to the Black Scholes option pricing model. From a stand-alone point of view, regardless of career reputation and liquidation threats, a hedge fund manager holding such at-the-money options have economic incentives to increase risk at mid-year for her own benefit. This rationale partially explains the overall positive risk-shifting at mid-years among hedge fund managers across all risk styles, as reflected in Table 2.1.

Thus far, we have depicted a sketch picture for the incentives from the two fees. We suspect that hedge fund managers are all willing to play tournament game to increase management fee, for the incentive from the performance-based fee is at least as strong. We conjecture that rational hedge fund managers shall balance the two incentives in making risk-shifting decisions. In the following section, we attempt to confirm our conjecture by

[4] Anecdotal evidence shows that the occurrence of a hurdle rate outside the 0%-8% range is rather rare.

reexamining the tournament behavior of hedge fund managers.

2.4 Contingency Table Analyses

A contingency table test is suitable for detecting the mutual dependence between two random variables. With respect to tournament behaviors, contingency table analyses are used to test whether mid-year losers tend to increase their portfolio risk in the second half year. In BHS's work, mid-year losers among mutual fund managers are identified based on the ranking of their accumulated returns over the first half calendar year. The bottom 50% of mutual fund managers are defined as mid-year losers and the top 50% as mid-year winners. The risk-shifting between the first and second half year for fund i is captured by RAR (the risk adjustment ratio) defined as follows,

$$RAR_i = \frac{\sigma_{1,i}}{\sigma_{2,i}} \tag{2.1}$$

Where $\sigma_{1,i}$ and $\sigma_{2,i}$ are the standard deviation of fund returns over the first and second half year, respectively. All RARs within a risk style are then ranked and a fund that has an RAR above/below the median is defined as a high RAR/ low RAR fund. A contingency table then allocates to 2x2=4 cells the proportion of funds that corresponds to loser & high RAR, loser & low RAR, winner & high RAR and winner & low RAR. The tournament theory predicts that mid-year losers have greater incentives than mid-year winners to boost performance ranking by aggressively increase risk taking in the second half year. Therefore, without the presence of tournament behavior, both mid-year winners and losers should have equal tendency to increase or decrease their risk and the corresponding cells in the contingency table should not be statistically different.

2.4.1 BHS and BGP Tests for Tournament

We first replicate the contingency table methodology in BHS(Brown, Harlow and Starks (1996))'s seminal work for mutual funds and BGP(Brown, Goetzmann and Park (2001))'s test for tournament for hedge funds CTAs on our sample data and report the results in Table 2.3. In this table, we test for the existence of tournament among hedge fund managers driven by incentives from both relative ranking and absolute performance. Incentives from relative performance refer to the relative ranking with peer mangers, while those from absolute performance are related to whether a hedge fund under management is currently below a High Water Mark (HWM)[5].

Panel A reports the contingency table conducted on the whole data sample that covers a 15-year time period from Jan. 1994 to Dec. 2008. The one-degree-of-freedom Chi-squared statistic of 35.50 rejects the null hypothesis that there is no tournament behavior driven by relative performance. The result indicates that on average, hedge fund managers respond to mid-year underperformance by taking relatively higher risk than style peers. However, by contrast, hedge fund managers that have not recovered previous loss by mid years do not significantly take on riskier portfolio management in the second half year.

Panel B details the contingency table analyses for each calendar year from 1994 to 2008. Out of the 15 years, tournament behavior driven by relative performance is significant at 1% confidence level in 9 years, lending support for the consistency of tournament behavior in the recently one decade and half. By contrast, only in 3 years can we find evident tournament behavior that is driven by absolute performance.

Panel C exhibits how tournament behavior prevails in different risky strategies of hedge funds. The result shows that 5 out of 11 strategies demonstrate risk tournament of relative performance over the sample period, while only three strategies participate in risk tourna-

[5]An alternative version of tournament behavior other than that in Brown, Harlow and Starks (1996) is first proposed by Brown, Goetzmann and Park (2001), who argue that if a hedge fund is below its HWM, as a result the manager would worry that she cannot charge incentive fees at year end, then she has greater incentives to inflate risk in the second half year in hope that the fund will exceed the HWM at year end.

ment driven by absolute performance. In accordance with Aragon and Nanda (2009), in Panel D we find that tournament is more evident during the incubation period of a hedge fund than after the hedge fund is added to TASS database,

2.4.2 Additional Contingency Table Tests

1. Fund-level Test

The estimate of half-year standard deviation for each fund is based on the 6 observations of month-end returns that are reported by TASS database and therefore has substantial estimation errors. The true return-generating process of a hedge fund is almost continuous. However, unlike U.S mutual funds, the hedge fund industry is not required by regulation or law to disclose performance to public on a daily basis. Therefore, the true return-generating process of a hedge fund is secretive to outside investors. Mainstream hedge fund databases record hedge fund performance on a monthly basis and as a result, we are only able to collect at most 12 sample points in a year for a hedge fund and use them to estimate the population standard deviation for each half year. The measurement error is further amplified when we divide the standard deviation of the first half year by that of the second. As an effort to cope with the estimation error problem, we use the Brown and Forsythe (1974)'s nonparametric test for homogeneity of variance to form a subsample of data that is only composed of those fund-years in which a manager significantly shift risk between the first and the second half-years.

The Brown and Forsythe's nonparametric test is a statistical technique that is originated from the Levene test for heterogeneity in variance. It calculates this absolute deviation from the sample median for each observation, and then uses ANOVA to test whether the means of this quantity are the same for all of the populations. The Brown and Forsythe's test does not require parametric assumptions about the underlying probability distributions of the two populations in comparison. The null hypothesis and alternative hypothesis are as following,

$$H_0 : \sigma_{1,i} = \sigma_{2,i}$$
$$H_1 : \sigma_{1,i} \neq \sigma_{2,i} \tag{2.2}$$

We then conduct this test on each fund and retain those fund-years that reject the above null hypothesis at a significance level of 10%. As a result, the sample size declines to 2545 fund-years, since the rest fund-years do not demonstrate statistically significant risk-shifting between the first and second half-years. Table 2.3 reports the results of the fund-level test in which we find little evidence of tournament behavior when monthly returns are used to measure risk shifting.

2.Strategy-level Test

Another limitation of the original contingency table test is that the excess risk-taking is defined in relative terms. For example, In BHS and BGP, second half-year risk-takers are defined as managers whose standard deviation ratios are below the median. Risk shifting of mid-year underperformers is found more aggressive than peers. However, this finding does not indicate whether the risk taking behavior is actually intensified due to the mid-year underperformance. For example, a hedge fund that has a risk ratio of 0.8 may have been found an excess risk-taker in a tournament, only because the average risk ratio is 0.75, despite that in fact the manager reduces her risk in the second half-year. The distinction between relative and absolute risk-shifting has critical economic implication from an investor's perspective. Compared to absolute risk-shifting, relative risk-shifting may not indeed increase the risk level of investors' capital. In view of the above, we next conduct another innovative test for tournament, requiring the median risk ratio of a risk strategy for a particular calendar year is either significantly greater or smaller than 1. We are mostly interested in finding out whether mid-year underperformers increase portfolio risk in the second half-year when on average style peers choose to reduce risk. If such behavior is detected, then it lends strong evidence to tournament theory.

The median RAR of each risk style is also subject to measurement error and as a result we cannot compare it directly to 1 to determine whether a risk style as a whole has a tendency to increase or decrease risk in a particular calendar year. We then use bootstrapping technique to determine the confidence interval for the median RAR of each risk style for each calendar year. If the lower bound of the confidence interval is higher than 1, then this risk style in this year is identified as risk seeking'; if the upper bound of the confidence interval is lower than 1, then this risk style in this year is identified as risk budgeting'. Bootstrapping is a nonparametric re-sampling technique and does not require any distributional assumptions about the median RAR. It is very useful especially when the assumption of normality does not hold and when we need to make inferences on a non-linear combination of variables, such as a ratio. We employ 10000 replications in bootstrapping each risk style for each year. Out of the 171 style-years, 57 style-years are classified as risk seeking' and 41 style-years are classified as risk budgeting'. We now constrain our sample in the risk budgeting' category and conduct another contingency table test for tournament. The results are reported in Table 2.4. We find that tournament behavior is rarely present in data. The results indicate that the tournament behaviors among hedge fund managers are dominated by relative rather than absolute risk taking.

In all, contingency table analyses provide very weak evidence that hedge fund risk shifting between the first and second half year is motivated by mid-year relative performance. In the next section, we perform regression analyses to further investigate the factors that affect the risk taking behavior of hedge fund managers.

2.5 Multivariate Regression Analyses

In this section, we use multivariate regression models to detect what factors, if not tournament, drive hedge fund managers' risk shifting decisions in the middle of a year.

Panel data of 12 hedge fund risk styles from 1994 through 2008 are used in all regressions and the dependent variable is the change in standard deviation of a hedge fund between the two halves of a calendar year.

$$\Delta\sigma_i = \sigma_{2,i} - \sigma_{1,i} \tag{2.3}$$

2.5.1 Control Variables

Given the property of the panel data in use, we include year dummies and risk style dummies to account for both the time and style fixed effects. Besides, we also adopt the following variables as controls,

1. Vix, The average of CBOE VIX Index in the first half of each calendar year, and ΔVix, the semi-annual change of Vix. These two variables control for market risk and its mid-year shifting.

2. $\sigma^{Index_j} \cdot \boldsymbol{I}^j$, standard deviation of the Credit Suisse Hedge Fund Index for risk style j, and its change between two year halves, $\Delta\sigma^{Index_j} \cdot \boldsymbol{I}^j$. These two variables control for style-specific risk and its mid-year shifting.

3.$\sigma_{1,i}$, is six-month lagged standard deviation of the same fund to control for the magnitude of individual fund's risk taking.

4. $\mathbf{I}^{HWM}$, is a High Water Mark dummy. It is included as control because interactive terms of this variable will be examined as experimental variables.

2.5.2 Experimental Variables

Of central interest in the paper is whether a hedge fund's risk-shifting decision is driven by relative or absolute performance, or both. Therefore, we include the following explanatory variables in regression models to test for their linear relations to individual hedge funds' mid-year risk shifting.

1. $Rank_{i,t}$, is the ranking of cumulative returns as of the end of June in year t of hedge

fund i within risk style. Rankings close to 0% represent bottom performers, and to 100%, top performers. If hedge fund managers play tournament games, then the coefficient should be significantly positive.

2. $AbsIncentive$, equal to $Moneyness \times Incentivefee$, is a hedge fund's moneyness at the end of June, as defined previously, scaled by its incentive fee rate. This variable measures the monetary motivation from absolute performance. Higher incentive fees imply stronger drives. We conjecture that positive moneyness leads to profit lock-in and therefore reduced risk, while negative moneyness results in excessive risk-taking and therefore increased volatility.

3. In order to investigate the impact of the positive and negative absolute performance on risk-shifting, respectively, we decompose the variable $AbsIncentive$ into two parts, and use them as separate explanatory variables.

$$AbsIncentive^{+} = max\{AbsIncentive, 0\} \geq 0 \tag{2.4}$$

$$AbsIncentive^{-} = min\{AbsIncentive, 0\} \leq 0 \tag{2.5}$$

By definition, these two variables add up to $AbsIncentive$ itself.

4. We include two interaction terms, $\mathbf{I}^{HWM} \cdot AbsIncentive^{+}$ and $\mathbf{I}^{HWM} \cdot AbsIncentive^{-}$ to examine the influence that the HWM provision exerts on hedge fund managers' risk shifting decisions.

2.5.3 Panel Regression Models

Model (1):

$$\begin{aligned} \Delta\sigma_{i,t}^{j} = {} & \alpha + \beta \cdot Rank_{i,t} + \gamma_1 \cdot Vix_t + \gamma_2 \cdot \Delta Vix_t + \gamma_3 \cdot \sigma_t^{Index_j} \cdot \boldsymbol{I}^j \\ & + \gamma_4 \cdot \Delta\sigma_t^{Index_j} \cdot \boldsymbol{I}^j + \gamma_5 \cdot \sigma_{1,i,t} + \sum_k \delta_k \cdot YearDummy_k + \sum_l \lambda_l \cdot StyleDummy_l + \varepsilon_{i,t} \end{aligned} \tag{2.6}$$

Model (1) tests for the linear relation between the change in risk of individual funds at mid-year and their performance ranking among style peers, after controlling for risk-taking and risk-shifting at economy level, strategy level and fund level.

Model (2):

$$\begin{aligned}\Delta\sigma_{i,t}^{j} &= \alpha + \beta \cdot AbsIncentive_{i,t} + \gamma_1 \cdot Vix_t + \gamma_2 \cdot \Delta Vix_t + \gamma_3 \cdot \sigma_t^{Index_j} \cdot \boldsymbol{I}^j \\ &+ \gamma_4 \cdot \Delta\sigma_t^{Index_j} \cdot \boldsymbol{I}^j + \gamma_5 \cdot \sigma_{1,i,t} + \sum_k \delta_k \cdot YearDummy_k + \sum_l \lambda_l \cdot StyleDummy_l + \varepsilon_{i,t}\end{aligned} \tag{2.7}$$

Model (2) tests for the linear relation between the change in risk of individual funds at mid-year and their absolute performance incentive measure, after controlling for risk-taking and risk-shifting at economy level, strategy level and fund level.

Model (3):

$$\begin{aligned}\Delta\sigma_{i,t}^{j} &= \alpha + \beta_1 \cdot Rank_{i,t} + \beta_2 \cdot AbsIncentive_{i,t} + \gamma_1 \cdot Vix_t + \gamma_2 \cdot \Delta Vix_t + \gamma_3 \cdot \sigma_t^{Index_j} \cdot \boldsymbol{I}^j \\ &+ \gamma_4 \cdot \Delta\sigma_t^{Index_j} \cdot \boldsymbol{I}^j + \gamma_5 \cdot \sigma_{1,i,t} + \sum_k \delta_k \cdot YearDummy_k + \sum_l \lambda_l \cdot StyleDummy_l + \varepsilon_{i,t}\end{aligned} \tag{2.8}$$

Model (3) include both relative rankings and absolute performance incentive measure, after controlling for risk-taking and risk-shifting at economy level, strategy level and fund level.

Model (4):

$$\begin{aligned}\Delta\sigma_{i,t}^{j} &= \alpha + \beta_1 \cdot Rank_{i,t} + \beta_2 \cdot AbsIncentive_{i,t}^{+} + \beta_3 \cdot AbsIncentive_{i,t}^{-} \\ &+ \gamma_1 \cdot Vix_t + \gamma_2 \cdot \Delta Vix_t + \gamma_3 \cdot \sigma_t^{Index_j} \cdot \boldsymbol{I}^j + \gamma_4 \cdot \Delta\sigma_t^{Index_j} \cdot \boldsymbol{I}^j \\ &+ \gamma_5 \cdot \sigma_{1,i,t} + \sum_k \delta_k \cdot YearDummy_k + \sum_l \lambda_l \cdot StyleDummy_l + \varepsilon_{i,t}\end{aligned} \tag{2.9}$$

Model (4) distinguishes whether a hedge fund is above or under the high water at mid-year, after controlling for risk-taking and risk-shifting at economy level, strategy level and fund level.

Model (5):

$$
\begin{aligned}
\Delta\sigma_{i,t}^{j} = {} & \alpha + \beta_1 \cdot Rank_{i,t} + \beta_2 \cdot AbsIncentive_{i,t}^{+} + \beta_3 \cdot AbsIncentive_{i,t}^{-} \\
& + \beta_4 \cdot AbsIncentive_{i,t}^{+} \cdot \mathbf{I}^{HWM} + \beta_5 \cdot AbsIncentive_{i,t}^{-} \cdot \mathbf{I}^{HWM} \\
& + \gamma_1 \cdot Vix_t + \gamma_2 \cdot \Delta Vix_t + \gamma_3 \cdot \sigma_t^{Index_j} \cdot \boldsymbol{I}^j + \gamma_4 \cdot \Delta\sigma_t^{Index_j} \cdot \boldsymbol{I}^j + \gamma_5 \cdot \sigma_{1,i,t} \\
& + \gamma_6 \cdot \mathbf{I}^{HWM} + \sum_k \delta_k \cdot YearDummy_k + \sum_l \lambda_l \cdot StyleDummy_l + \varepsilon_{i,t}
\end{aligned}
\tag{2.10}
$$

In addition to Model (4), Model (5) contains two interaction variables between the HWM dummy and absolute performance incentive measure.

2.5.4 Regression Results

Table 2.5 reports the regression results of the above five models. All regressions are conducted at the hurdle rate of 4%. All tests correct for heteroscedasticity in residual errors and diagnostic analyses do not detect mutlilinearity and serial correlation.

Among control variables, the change in risk of VIX and style-specific indices both demonstrate positive and significant coefficients across all models, implying that individual hedge fund managers' risk-shifting decisions are remarkably influenced by market condition and style peers. Also, risk-shifting is mean reverting, based on the significantly negative coefficient of individual funds' lagged risk.

It can be observed from Model (1) that when performance ranking alone is considered as an explanatory variable, its coefficient is negative and significant, indicating tournament behavior of hedge fund managers. This result is consistent with the contingency table test in Table 2.3 and partially explains why existing literature has documented hedge fund tournament.

Results of Model (2) exhibit that when absolute performance measure is examined alone, its coefficient is negative and significant, indicating that when a hedge fund is under the water at mid-year, the manager tends to increase risk and when the fund is above the water, the manager tends to decease risk.

Model (3) contains both the relative and absolute performance measures and regression results show that regarding risk-shifting, the motivation from absolute performance dominates that from relative performance, for the coefficient of Moneyness*Ifee remains negative and significant, while the coefficient of relative ranking loses its statistic significance.

Model (4) is designed to detect whether mid-year risk-shifting decisions of hedge fund managers are more responsive to underperformance or outperformance relative to mangers' own benchmark (HWM, hurdle, or both). Results illustrate that underperforming hedge fund managers eagerly take risk and somewhat surprisingly, outperforming managers do not tend to decrease risk to lock in profits and fees. However, the risk-taking on the upside is much more moderate than on the downside.

Model (5) examines whether HWM has any meaningful impact on hedge fund managers' risk-shifting decisions by including interaction terms in the regression model. Interestingly, HWM does rein in excessive risk taking when a fund is under the water. On one hand, an underperforming hedge fund with a HWM takes 12 percentage points less risk than an underperforming hedge fund without one, about one-third less risky than the latter. On the other hand, however, HWM does not significantly affect already outperforming hedge funds.

In the above regression analyses, some unique features of hedge fund risk-shifting have been revealed. First, hedge fund managers respond to absolute performance more prominently than to relative ranking. Second, hedge fund managers respond to downside absolute performance more drastically than to upside absolute performance. Third, HWM functions well in reining in excessive risk-taking on the downside, while having no meaningful impact on the upside.

While the above regression analyses reveal significant relation between hedge funds' mid-year risk-shifting and hedge fund managers' incentive from option-like fees, some embedded non-linearity may not be readily unveiled by such linear regressions. We next use sorted portfolios to further study the binary relation between fee incentives and risk-shifting behaviors from a different perspective.

2.6 Performance and Flow Consequences of Risk Taking

In this section, we examine whether mid-year risk-shifting has any implication for subsequent performance and capital flows.

Within each risk strategy in a particular year, we sort individual hedge funds, according to their mid-year risk taking, into quintiles and obtain 5 x 11=55 portfolios. We compute the equally-weighted average of risk-shifting, change in half-year cumulative returns and change in moneyness between two year halves for each portfolio. We report the results in Table 2.6.

Table 2.6 shows that, in general, mid-year risk shifting does not improve post-shifting performance. Specifically, in 9 out of 11 risk strategies, Portfolio 1 (the most aggressive risk takers) result in the worst post-shifting performance, except for Dedicated Short Bias and Managed Futures. Besides, in 7 out of 11 risk strategies, Portfolio 1 (the most aggressive risk takers) result in the worst improvement in the moneyness of fund manager incentive contracts, except for Dedicated Short Bias, Global Macro, Long/Short Equity Hedge and Managed Futures. We therefore conclude that aggressive risk taking on average does not create value for hedge fund investors nor improve the personal compensation of hedge fund managers. Thus, it should not be a consequence of long-run market equilibrium, but rather reflects ill-aligned interest caused by short-term incentives. This finding is in line with Huang, Sialm and Zhang (2010), who find that the most actively risk-shifting mutual funds have the poorest post-shifting performance and they attribute this issue to agency problems.

We also compute the equally-weighted average of risk-shifting, change in cumulative net investor cash flows and between year halves and change in net investor cash flows measured in percentage of year-beginning AUM. We report the results in Table 2.7[6].

Table 2.7 shows that Portfolio 1 (the most aggressive risk takers) in all risk strategies results in less net cash inflows post-shifting than the first year half. Besides in 9 out of 11 risk strategies, Portfolio 1 (the most aggressive risk takers) results in deteriorated net cash inflows measured in percentage. We therefore conclude that aggressive risk taking on average does not attract outside capital nor increases the size of capital pool.

2.7 Robustness Checks

2.7.1 Alternative Model Specification

We perform the following checks to ensure the robustness of our results.

(1) Alter the specification of the dependent variable in the multivariate regression models.

We use the change in tracking error to replace the change in standard deviation, assuming that a hedge fund's active benchmark is the index return of the same risk strategy. That is,

$$\Delta\sigma_i^{TE} = \sigma_{2,i}^{TE} - \sigma_{1,i}^{TE} \tag{2.11}$$

where

$$\sigma_{j,i}^{TE} = \sqrt{E[r_{i,t} - r_{i,t}^{Index}]^2} \tag{2.12}$$

(2)Control for liquidity shocks

Since hedge funds as a group take on remarkably high level of liquidity risk and serve

[6] Many hedge funds do not routinely report to Lipper TASS database their AUM on a monthly basis. As a result, we have to purge about one third of observations that do not have a positive AUM number. Therefore, the number of observations in each portfolio within the same risk strategy in Table 2.7 generally does not equal.

as a provider of liquidity to the market, (see, e.g. Teo (2010), Sadka (2009) and Cao, Chen, Liang and Lo (2009)) , they are, therefore, inevitably subject to the so-called 'liquidity spiral', especially during adverse market liquidity shocks (see Boyson, Stahel and Stulz (2010) and Brunnermeier and Pedersen (2009)). That is, when facing adverse funding liquidity shocks during crises, hedge funds usually decrease their leverage and meet redemption requirements by selling the most liquid assets.Such sale will reduce a hedge fund's ability to provide liquidity to the market and as a result, will tighten market liquidity on aggregate. The shrinking market liquidity, in turn, will intensify the liquidity squeeze and further reduce the value of the illiquid asset holdings of hedge funds. If strong enough, the liquidity spiral can dry out the funding liquidity and the market value of holding portfolios of a hedge fund very fast, resulting in unintentionally changed total risk. In order to exclude the alternative explanation from adverse liquidity shocks, we include the control variable $\Delta log(AUM)$ in the multivariate regression models introduced in Section 4 to account for the potential influence of the 'liquidity spiral' on risk changing.

(3)Alternative hurdle rates.

We use the three-month T-bill rate to replace the previously used fixed hurdle rate and to capture the variation of hurdle rates used to benchmark hedge fund managers through time.

Table 2.8 reports the results. We observe that compared to Table 2.5, Table 2.8 does not display notable differences on the sign, magnitude and significance of regression coefficients. We still observe that the incentive of risk taking is much stronger from underperformance of benchmark than from outperformance of benchmark. Also, HWM reduces about one third of risk-taking induced from downside performance. Besides, the change in size control variable has a negative and significant coefficient for all five models, indicating that decease in size explains increase in measured risk. However, our main results still hold after controlling for change in size.

2.7.2 Sorted Portfolios by Relative Performance

We first sort all individual hedge funds in sample, according to their relative performance ranking within risk style at mid-year, into quintiles and obtain 5 x 11=55 portfolios. We then compute the equally-weighted average of risk-shifting, half-year cumulative return and moneyness for each portfolio. Results are reported in Table 2.9 and Figure 2.1.

If tournament is present among hedge funds, then we shall expect to observe decreasing risk-shifting from worst performers' portfolios through to best performers' portfolios. In Table 2.9, however, such trend is not present. To the contrary, 9 out of 11 hedge fund strategies (with the exception of Managed Futures and Fixed Income Arbitrage), demonstrate some reverse-U shape of risk-shifting with respect to performance ranking. That is, neither top nor bottom performers, but rather some medium performers, change risk the most dramatically at mid-year. Figure I visualizes the reverse-U shape in a more evident manner.

This finding is key to understanding the drive for hedge fund managers' risk-shifting behaviors. The reverse-U shape that cannot be explained by tournament behavior resembles the bell curve of Vega, the first derivative of a European call option with respect to its volatility. In other words, a hedge fund manager has the strongest economic drive to increase risk when her own incentive contract, which can be considered as a long European call with a strike of historical high, is currently at the money. Our empirical evidence supports this explanation for 9 out of 11 risk strategies except for 2 fixed-income related strategies (Fixed Income Arbitrage and Managed Futures). Most portfolios that shift risk at mid-year in the most aggressive manner have moneyness around 0, according to Table 2.9.

2.8 Concluding Remarks

In this paper we provide a variety of contingency table and multivariate regression analyses on the risk tournament behaviors of hedge fund managers and their risk-shifting decision making in response to relative performance, absolute performance and other factors.

The findings in these analyses shed light on understanding the relation between managerial compensation, incentives and risk taking among the hedge fund industry along the following aspects.

(1) Hedge funds do not exhibit strong collective risk tournament behaviors driven by relative performance ranking because unlike mutual fund managers, hedge fund managers' compensation incentives do not solely come from attracting outside capital and charging flat fees on an increasing basis. In addition, hedge fund managers have strong incentives to enter the profit-sharing zone because of the lucrative 2-20 fee structure. Therefore, the combined incentives to beat peers and to outperform the past affect hedge fund managers' risk-changing decisions in a more profound way.

(2) On aggregate, hedge fund managers seem to respond to absolute underperformance more actively than to relative underperformance when making risk-taking decisions.

(3) Downside performance provides much greater incentives for hedge fund managers to increase risk than upside performance does mainly due to the different slopes of the pay-performance curve on the downside and upside. An economic implication is that if the upside reward is restricted and the downside performance results in punishment, then the excess risk-taking can be hopefully reduced.

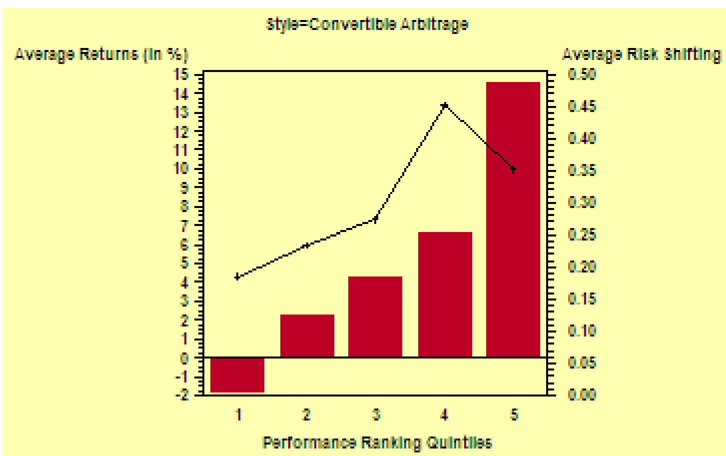
(4) The HWM functions well in reining in excess risk-taking. One explanation is that HWM extends a manager's investment horizon and by Panageas and Westerfield (2009), a prolonged horizon can effectively lessen the manager's risk appetite.

(5) Risk shifting does not bring either performance or cash inflows. Reducing the sensitivity of hedge fund managers' pay to their absolute performance could be one remedy for such value-deteriorating behavior.

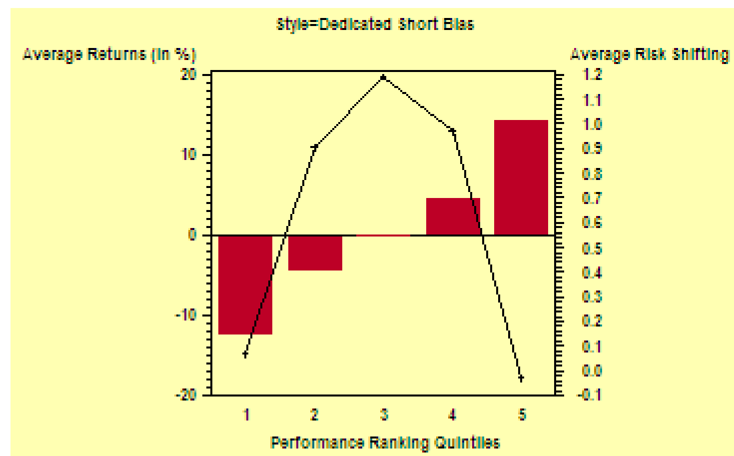
Figure 2.1 Sorted portfolios by Performance Ranking

Figure 2.1 depicts the average returns (the bars) and average risk shifting, $\Delta\sigma$, (the lines) for 5 equally-weight hedge fund portfolios in each risk strategy. Portfolios are formed by ranking each individual hedge fund's performance within a calendar year with strategy peers. Portfolio 1 contains bottom performers and Portfolio 5 contains top performers for each risk strategy. The moneyness of each portfolio is estimated by assuming the hurdle rate is 4%.

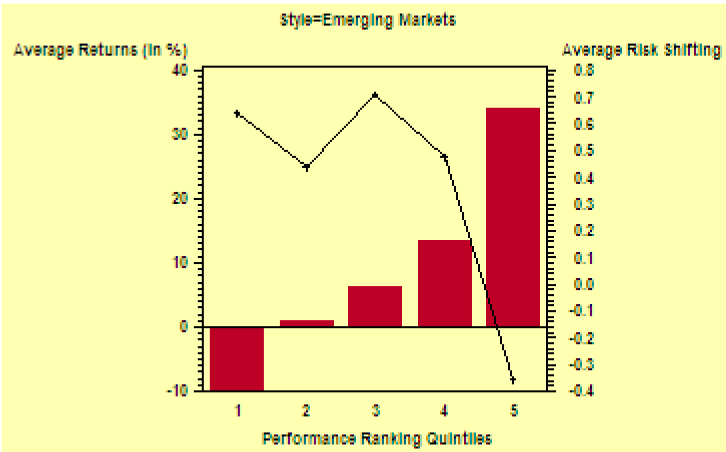
Convertible Arbitrage



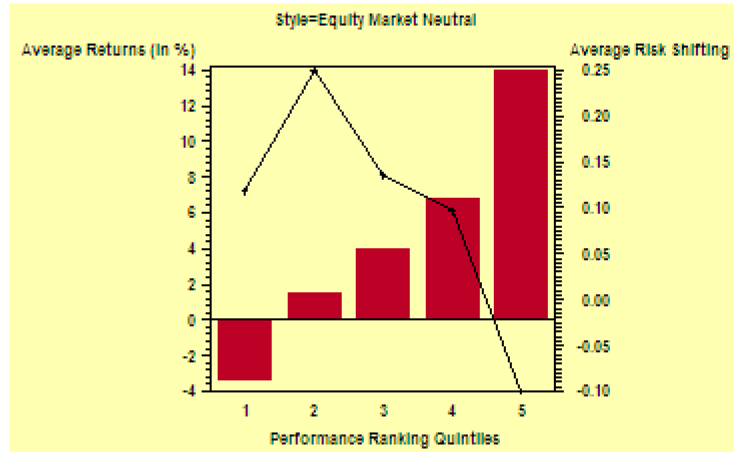
Dedicated Short Bias



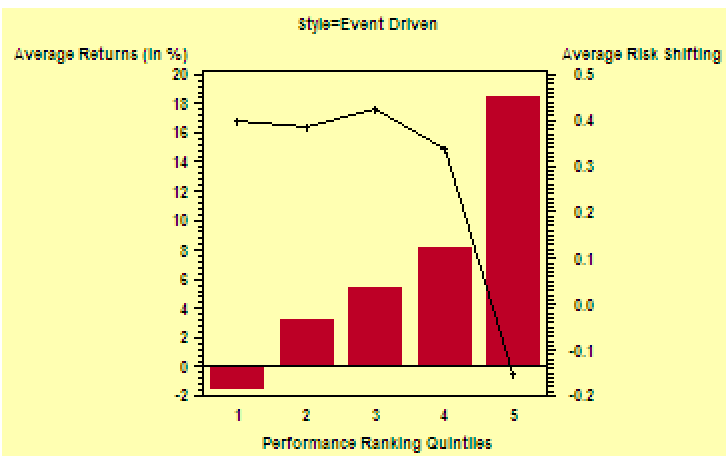
Emerging Markets



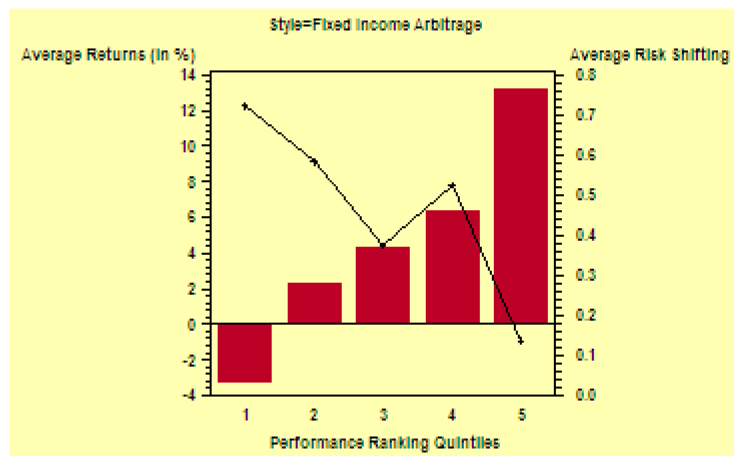
Equity Market Neutral



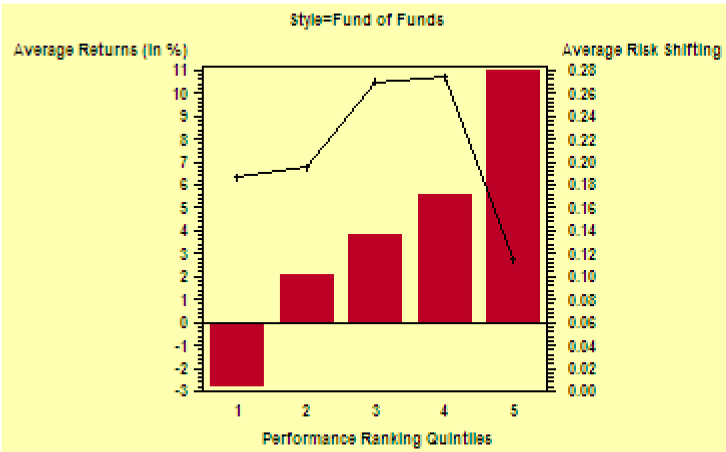
Event Driven



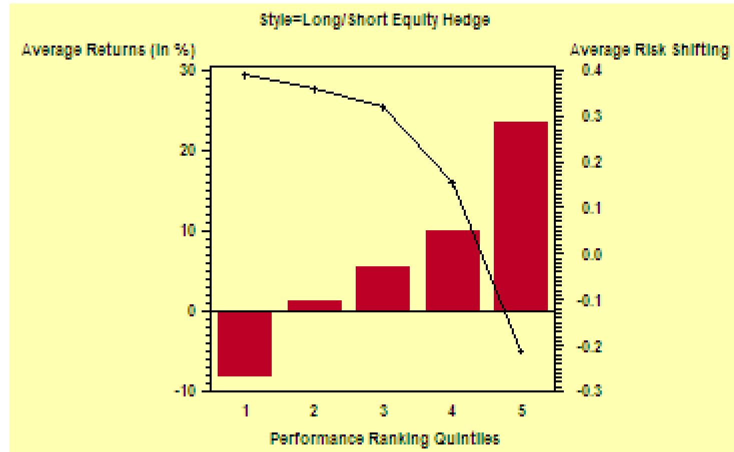
Fixed Income Arbitrage



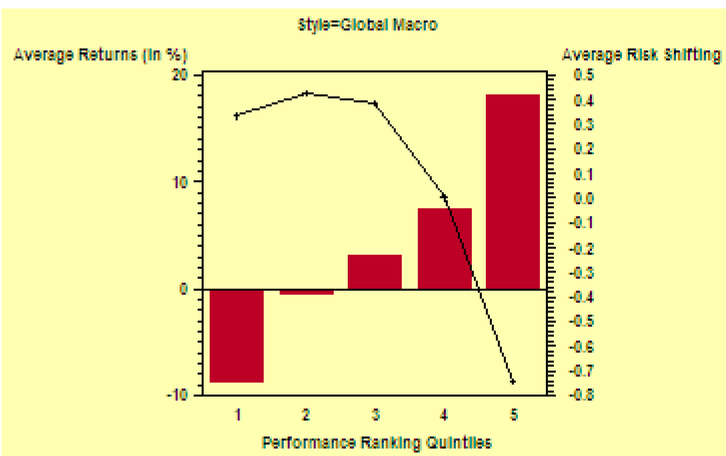
Fund of Funds



Long/Short Equity Hedge



Global Macro



Managed Futures

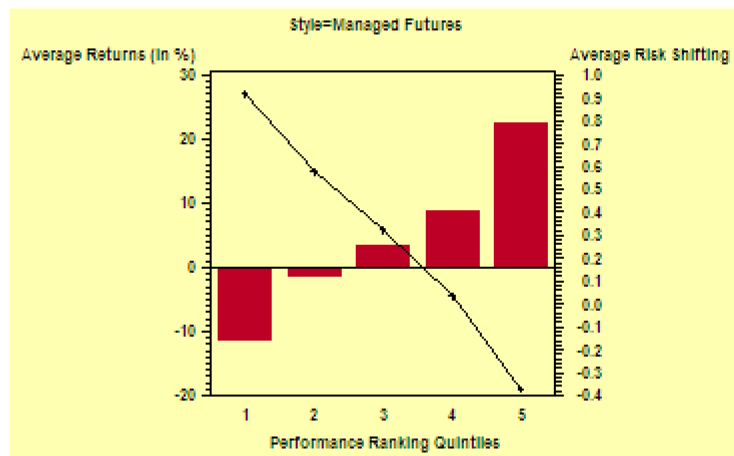


Table 2.1 Summary Statistics

Table 2.1 presents summary statistics of monthly returns and mid-year risk shifting of equally-weighted hedge fund portfolios and hedge fund indices in each risk strategy over the period of 1994-2008. Both individual hedge fund and hedge fund index data come from the Lipper TASS database. We benchmark each risk group of individual hedge funds with the Credit Suisse/Tremont Hedge Fund Index USD of the corresponding risk strategy, with the only exception of Fund of Hedge Funds, for which we use TASS Fund of Funds Universe Average.

Monthly returns, r, are measured in %. Risk shifting for fund i in calendar year t, σ_{2i}-σ_{1i}, is defined as the excess standard deviation of the second half year over the standard deviation of the first half year.

	Individual Hedge Funds					Hedge Fund Indices			
	Number (N)	Monthly Returns (r)		Risk Shifting (σ_{2i}-σ_{1i})		Monthly Returns (r)		Risk Shifting (σ_{2i}-σ_{1i})	
		Mean	Std	Mean	Std	Mean	Std	Mean	Std
All Funds	7206	0.53	1.23	0.25	2.66	0.73	2.30	0.29	1.52
Convertible Arbitrage	204	0.52	0.64	0.29	1.99	0.46	1.98	0.09	0.94
Dedicated Short Bias	43	0.69	1.46	0.67	4.05	0.05	4.90	0.94	2.12
Emerging Markets	430	0.47	2.00	0.38	4.03	0.65	4.58	0.56	2.19
Equity Market Neutral	367	0.49	0.77	0.10	1.58	0.52	3.18	1.30	4.29
Event Driven	596	0.67	1.17	0.28	2.01	0.78	1.76	0.40	0.89
Fixed Income Arbitrage	302	0.48	1.05	0.47	2.37	0.30	1.73	0.44	0.85
Fund of Hedge Funds	1646	0.27	0.99	0.21	1.73	0.48	1.75	0.17	0.78
Global Macro	367	0.56	1.40	0.07	2.69	1.03	3.05	0.33	0.97
Long/Short Equity Hedge	2168	0.65	1.29	0.21	3.10	0.82	2.95	0.14	1.42
Managed Futures	575	0.78	1.17	0.33	3.38	0.64	3.44	0.20	1.47
Multi-Strategy	508	0.46	1.24	0.38	2.25	0.59	1.58	0.41	0.64

Table 2.2 Hedge Fund Compensation Structure and Fee Incentives

Table 2.2 reports summary statistics of the compensation structure of 7206 hedge funds over the period of 1994-2008. Management Fee and Incentive Fee are reported to Lipper TASS database in percentage of a fund's NAV and excess return, respectively. HWM Dummy equals one when a hedge fund features a High Water Mark provision and zero otherwise.

Also reported in Table II are estimates that measure a hedge fund manager's monetary incentives from fees. Paid-out Incentive Fee measures the fraction of a hedge fund's NAV that the manager charges investors as the incentive fee, assuming the fee is accrued monthly and collected yearly. Mid-Year Moneyness is defined as $NAV^{June}/NAV^{HWM}-1$[1], considering a hedge fund's manager's incentive fee as a series of European call options with one-year expiration each. Time under High Water is the time length, measured in number of months, before a hedge fund manager is able to accrue the incentive fee during a calendar year. All these three variables are estimated and reported at hurdle rates of 0%, 4% and 8%.

	Min	**25^{th} Pctl**	**Mean**	**75^{th} Pctl**	**Max**	**Std**
Management Fee (in % of NAV annually)	0.00	1.00	1.47	2.00	10.00	0.68
Incentive Fee (in % of excess returns)	0.00	10.00	15.54	20.00	50.00	7.67
HWM Dummy	0.00	0.00	0.61	1.00	1.00	0.49
Paid-out Incentive Fee (in % of NAV annually)						
At hurdle rate= 0%	0.00	0.00	2.54	3.31	114.06	4.53
At hurdle rate= 4%	0.00	0.00	2.12	2.56	113.41	4.39
At hurdle rate= 8%	0.00	0.00	1.75	1.82	112.79	4.26
Mid-Year Moneyness						
At hurdle rate= 0%	-0.86	0.00	0.06	0.10	4.50	0.15
At hurdle rate= 4%	-0.87	-0.04	0.01	0.06	4.33	0.15
At hurdle rate= 8%	-0.87	-0.08	-0.03	0.02	4.18	0.14
Time under High Water (in months per year)						
At hurdle rate= 0%	0.00	0.00	3.32	6.00	12.00	4.26
At hurdle rate= 4%	0.00	3.00	6.48	11.00	12.00	4.25
At hurdle rate= 8%	0.00	6.00	8.72	12.00	12.00	3.71

[1] If a hedge fund has a HWM provision, then NAV^{HWM} equals historical high; otherwise, it equals the closing NAV of the previous year.

Table 2.3 Test of Tournament at Fund Level

The table reports the contingency table test for tournament behaviors at fund level among hedge fund managers using an innovative method. The time period is from 1994 to 2008. Only those fund-years that have passed the screening test are included in this test. That is, all fund-years in the sample demonstrate statistically significantly different standard deviation in the first and second half of the same calendar year at 5% level. For each calendar year, each hedge fund in the database is categorized into either the "underperformer" or "outperformer" group; dependent on its performance ranking based on accumulated returns up to the end of the estimation period (usually the first 6 months of a year but can vary) for the row of "Relative". For the row of "Incentive", "Underperformers" are defined as hedge funds that are currently below the high-water-mark, while "Outperformers" are defined as hedge funds that have exceeded the high-water-mark and therefore are entitled to charge incentive fees. Within each group, a hedge fund's risk-adjustment ratio (RAR) is calculated by dividing the standard deviation during the first half year by that during the second half year. Each fund is then further identified as being a "Low RAR" or "High RAR" fund. Low RAR corresponds to a volatility ratio less than the median, where High RAR corresponds to a ratio higher than the median. The Chi-square numbers represent the $\chi(1)$ statistics from the 2x2 contingency table. * and ** Indicate rejections of a two-sided test of the null hypothesis of an equal number of funds within each group at 5% and 1% significance levels, respectively.

Panel A reports the results where the median of RAR of a strategy is used as threshold to distinguish between Low RAR and High RAR funds, while Panel B uses "1" as the threshold, so that Low RAR funds decrease their standard deviation in the second half year and High RAR funds increase.

Panel A Median as threshold for RAR							
	Return less than Median (in %) (Underperformers)		Return greater than Median (in %) (Outperformers)		# of Obs.	Chi-Sq	p-value
	Low RAR	High RAR	Low RAR	High RAR			
Assessment Period: (6,6)							
Relative	23.11	28.44	22.47	25.98	4820	1.1693	0.2795
Absolute	10.52	11.76	35.06	42.66		1.4726	0.2249
Assessment Period: (7,5)							
Relative	20.12	27.11	20.80	31.96	3091	9.06	0.0727
Absolute	9.06	12.65	31.87	46.43		0.2289	0.6324

Panel B "1" as threshold for RAR							
	Return less than Median (in %) (Underperformers)		Return greater than Median (in %) (Outperformers)		# of Obs.	Chi-Sq	p-value
	Low RAR	High RAR	Low RAR	High RAR			
Assessment Period: (6,6)							
Relative	22.14	29.42	21.80	26.64	4820	2.1003	0.1473
Absolute	10.33	11.95	33.61	44.11		3.3040	0.0691
Assessment Period: (7,5)							
Relative	19.64	27.60	20.06	32.71	3091	4.0829	0.0833
Absolute	8.96	12.75	30.73	47.56		0.9003	0.3427

Table 2.4 Test for Tournament at Style Level

The table reports the contingency table test for tournament behaviors at fund style among hedge fund managers using an innovative method. The time period is from 1994 to 2008. Only those fund-years that have passed the screening test are included in this test. That is, all fund-years in the sample demonstrate statistically significantly different standard deviation in the first and second half of the same calendar year at 10% level. For each calendar year, each hedge fund in the database is categorized into either the “underperformer” or “outperformer” group; dependent on its performance ranking based on accumulated returns up to the end of the estimation period (usually the first 6 months of a year but can vary) for the row of “Relative”. For the row of “Incentive”, “Underperformers” are defined as hedge funds that are currently below the high-water-mark, while “Outperformers” are defined as hedge funds that have exceeded the high-water-mark and therefore are entitled to charge incentive fees. Within each group, a hedge fund’s risk-adjustment ratio (RAR) is calculated by dividing the standard deviation during the first half year by that during the second half year. A bootstrapping is then conducted on the sample pool of RARs in each strategy. If the resampled median of a strategy in a particular year is significantly larger than 1, then the strategy-year is labeled as “risk-seeking”, if less than 1, then “risk-budgeting”. Only fund-years that either have a “risk budgeting” or “risk seeking” strategy year are retained for the test.

In each subgroup, a hedge fund is then further identified as being a “Low RAR” or “High RAR” fund. Low RAR corresponds to a volatility ratio less than the median, where High RAR corresponds to a ratio higher than the median. The Chi-square numbers represent the $\chi(1)$ statistics from the 2x2 contingency table. * and ** Indicate rejections of a two-sided test of the null hypothesis of an equal number of funds within each group at 5% and 1% significance levels, respectively.

Panel A reports the results for the “risk-budgeting” subgroup and Panel A for the “risk-seeking” subgroup.

Panel A ‘Risk Budgeting’ style-years							
	Return less than Median (in %) (Underperformers)		Return greater than Median (in %) (Outperformers)		# of Obs.	Chi-Sq	p-value
	Low RAR	High RAR	Low RAR	High RAR			
Relative	25.35	24.53	24.74	25.38	11635	2.4563	0.1171
Absolute	11.93	11.38	38.16	38.53	11635	1.6796	0.1950

Panel B ‘Risk Seeking’ style-years							
	Return less than Median (in %) (Underperformers)		Return greater than Median (in %) (Outperformers)		# of Obs.	Chi-Sq	p-value
	Low RAR	High RAR	Low RAR	High RAR			
Relative	24.97	24.90	25.14	24.98	17155	0.0129	0.9094
Absolute	12.95	12.78	37.17	37.10	17155	0.0985	0.7537

Table 2.5 Multivariate Regression Analyses

This table reports the outputs of the following OLS regression model:

$$\Delta\sigma_{i,t}^{j} = \alpha + \beta_1 \cdot Rank_{i,t} (+\beta_2 \cdot AbsIncentive_{i,t}) + \beta_3 \cdot AbsIncentive_{i,t}^{+} + \beta_4 \cdot AbsIncentive_{i,t}^{-}$$
$$+\beta_5 \cdot AbsIncentive_{i,t}^{+} \cdot I^{HWM} + \beta_6 \cdot AbsIncentive_{i,t}^{-} \cdot I^{HWM} + \gamma_1 \cdot Vix_t + \gamma_2 \cdot \Delta Vix_t + \gamma_3 \cdot \sigma_t^{Index_j} \cdot I^{j}$$
$$+\gamma_4 \cdot \Delta\sigma_t^{Index_j} \cdot I^{j} + \gamma_5 \cdot \sigma_{1,i,t} + \gamma_6 \cdot I^{HWM} + \sum_k \delta_k YearDummy_k + \sum_l \lambda_l StyleDummy_l + \varepsilon_{i,t}$$

The dependent variable, $\sigma_{i,t}^{j}$, is the change in standard deviation of individual hedge funds between the first and second six months in a calendar year. $Rank_{i,t}$ is the percentile of performance ranking of a hedge fund relative to strategy peers at mid-year, 0% representing bottom performers and 100% top performers. AbsIncentive is defined as Moneyness*Icentive Fee. Its positive and negative parts are also included in Model (4). Two interaction terms of AbsIncentive with HWM provision dummy are introduced in Model (5).

Control variables include Vix_t, the contemporary VIX Index average, ΔVix_t, the semi-annual change in it, $\sigma^{Index_j} \cdot I^{Index_j}$, the first six-month standard deviation of Credit Suisse Tremont Hedge Fund Indices of 10 risk strategies[2], $\Delta\sigma^{Index_j} \cdot I^{Index_j}$, the semi-annual change in it, and $\sigma_{i,1}$, the first six-month standard deviation of individual hedge funds.

These tests correct for heteroscedasticity in residual errors and diagnostic analyses do not detect mutlilinearity and serial correlation. * and ** indicates statistical significance at 5% and 1% levels, respectively. All regressions control for the fixed effects of years and hedge fund strategies. The hurdle rate is set to 4% throughout this table.

[2] With the only exception of Fund of Hedge Funds, for which the TASS Fund of Funds Universe Average is used.

	α	β_1	β_2	β_3	β_4	β_5	β_6	γ_1	γ_2	γ_3	γ_4	γ_5	γ_6	Adj. R^2	DF.
Model (1)	0.33	-0.40^{**}						0.02	0.39^{**}	0.00	0.22^{**}	-0.35^{**}		28.20%	35520
	0.78	-9.44						0.78	3.65	-0.11	19.73	-77.39			
Model (2)	0.18		-0.42^{**}					0.01	0.51^{**}	0.00	0.22^{**}	-0.34^{**}		28.53%	35520
	0.42		-15.91					0.42	4.86	0.17	20.00	-76.18			
Model (3)	0.15	0.05	-0.48^{**}					0.01	0.52^{**}	0.00	0.22^{**}	-0.34^{**}		28.53%	35519
	0.37	0.86	-12.82					0.40	4.89	0.19	20.01	-76.15			
Model (4)	-0.14	0.17^{**}		0.06^{**}	-0.27^{**}			0.03	0.48^{**}	0.03	0.22^{**}	-0.40^{**}		29.85%	35518
	-0.33	3.24		7.82	-28.63			0.83	4.60	1.71	19.85	-80.65			
Model (5)	-0.18	0.24^{**}		0.05^{**}	-0.37^{**}	0.01	0.12^{**}	0.02	0.54^{**}	0.03	0.22^{**}	-0.40^{**}	-0.32	29.96%	35516
	-0.44	4.60		4.74	-22.40	1.10	7.42	0.66	5.12	1.75	19.68	-80.95	-0.30		

Table 2.6 Subsequent Performance after Risk-Shifting

This table reports the second-half-year cumulative return, year-end moneyness and change in risk, cumulative returns and moneyness between two halves of a calendar year for 5 equally-weight hedge fund portfolios in each risk strategy. Portfolios are formed by ranking each individual hedge fund's risk taking at mid-year. Portfolio 1 contains most aggressive risk takers and Portfolio 5 contains least aggressive takers each risk strategy. The moneyness of each portfolio is estimated by assuming the hurdle rate is 4%.

		1	**2**	**3**	**4**	**5**
Convertible Arbitrage	*ΔRisk*	2.98	0.38	-0.04	-0.35	-1.47
	Return	-3.94	4.52	3.83	3.89	3.72
	ΔMoneyness	-0.02	0.06	0.05	0.05	0.05
Dedicated Short Bias	*ΔRisk*	5.28	1.71	0.59	-0.43	-3.82
	Return	1.34	5.16	1.19	3.18	0.76
	ΔMoneyness	0.03	0.06	0.01	0.04	0.00
Emerging Markets	*ΔRisk*	6.04	1.41	0.08	-1.13	-4.48
	Return	-10.65	4.59	5.78	7.04	10.01
	ΔMoneyness	-0.06	0.08	0.08	0.10	0.15
Equity Market Neutral	*ΔRisk*	2.08	0.50	0.04	-0.37	-1.76
	Return	1.98	2.59	3.24	3.58	3.88
	ΔMoneyness	0.03	0.04	0.04	0.05	0.05
Event Driven	*ΔRisk*	2.74	0.63	0.11	-0.27	-1.81
	Return	-3.07	3.52	4.34	4.84	6.00
	ΔMoneyness	-0.01	0.05	0.06	0.06	0.09
Fixed Income Arbitrage	*ΔRisk*	3.34	0.48	0.07	-0.17	-1.36
	Return	-5.55	4.48	4.08	4.21	5.36
	ΔMoneyness	-0.04	0.06	0.06	0.06	0.07
Fund of Hedge Funds	*ΔRisk*	2.32	0.61	0.11	-0.30	-1.71
	Return	-0.43	2.18	2.58	3.36	2.97
	ΔMoneyness	0.00	0.03	0.03	0.04	0.04
Global Macro	*ΔRisk*	3.40	1.00	0.04	-0.80	-3.22
	Return	3.85	4.17	6.10	4.56	5.56
	ΔMoneyness	0.06	0.05	0.08	0.06	0.08
Long/Short Equity Hedge	*ΔRisk*	4.15	1.05	0.13	-0.74	-3.58
	Return	2.94	5.02	4.34	4.80	5.96
	ΔMoneyness	0.07	0.07	0.06	0.07	0.09
Managed Futures	*ΔRisk*	5.03	1.44	0.19	-1.00	-4.18
	Return	11.27	6.18	4.35	4.90	5.02
	ΔMoneyness	0.13	0.08	0.05	0.06	0.06
Multi-Strategy	*ΔRisk*	3.33	0.76	0.12	-0.33	-1.96
	Return	-0.46	2.57	4.33	3.51	5.84
	ΔMoneyness	0.02	0.04	0.06	0.05	0.07

Table 2.7 Subsequent Cash Flows after Risk-Shifting

This table reports change in cash flows between two year halves measured in both million U.S dollars and percentage of year-beginning NAV for 5 equally-weight hedge fund portfolios in each risk strategy. Portfolios are formed by ranking each individual hedge fund's risk taking at mid-year. Portfolio 1 contains most aggressive risk takers and Portfolio 5 contains least aggressive takers each risk strategy.

		1	**2**	**3**	**4**	**5**
All Funds	*N*	4460	4360	4320	4406	4465
	Δ*Risk*	3.17	0.97	0.19	-0.52	-2.58
	Δ *Cash Flows(in $ Mil.)*	-1.27	-1.51	-1.68	-1.60	-1.54
	Δ *Cash Flows(in %)*	-0.8%	-0.4%	-0.4%	0.2%	0.7%
Convertible Arbitrage	*N*	145	156	153	164	138
	Δ*Risk*	2.44	0.56	0.13	-0.18	-1.46
	Δ *Cash Flows(in $ Mil.)*	-3.70	0.08	-1.13	-2.64	-2.51
	Δ *Cash Flows(in %)*	-2.1%	-0.9%	0.2%	0.9%	-2.1%
Dedicated Short Bias	*N*	28	39	32	28	28
	Δ*Risk*	4.87	2.29	0.48	-0.49	-4.16
	Δ *Cash Flows(in $ Mil.)*	-2.18	0.20	0.25	0.14	-0.99
	Δ *Cash Flows(in %)*	-5.5%	-1.3%	-4.5%	5.0%	-9.1%
Emerging Markets	*N*	318	298	263	286	290
	Δ*Risk*	4.54	1.72	0.35	-0.93	-4.22
	Δ *Cash Flows(in $ Mil.)*	-1.65	-0.25	-0.81	-1.15	-1.97
	Δ *Cash Flows(in %)*	0.9%	-1.8%	-0.9%	0.9%	-0.3%
Equity Market Neutral	*N*	203	242	228	225	232
	Δ*Risk*	1.87	0.52	0.09	-0.38	-1.61
	Δ *Cash Flows(in $ Mil.)*	-1.91	-2.14	-1.91	-0.56	-0.35
	Δ *Cash Flows(in %)*	-3.0%	0.9%	-2.2%	-0.9%	-1.6%
Event Driven	*N*	403	394	392	411	396
	Δ*Risk*	2.27	0.75	0.26	-0.14	-1.73
	Δ *Cash Flows(in $ Mil.)*	-1.07	-1.41	-0.97	-2.57	-1.41
	Δ *Cash Flows(in %)*	-0.9%	0.9%	-2.2%	1.4%	3.4%
Fixed Income Arbitrage	*N*	188	203	204	208	198
	Δ*Risk*	2.68	0.74	0.20	-0.13	-1.25
	Δ *Cash Flows(in $ Mil.)*	-3.48	-8.33	-1.01	0.54	0.05
	Δ *Cash Flows(in %)*	0.5%	-0.4%	3.4%	2.0%	1.0%
Fund of Hedge Funds	*N*	895	909	884	927	884
	Δ*Risk*	1.87	0.56	0.22	-0.20	-1.41
	Δ *Cash Flows(in $ Mil.)*	-1.67	-1.62	-3.30	-1.94	-1.37
	Δ *Cash Flows(in %)*	-1.0%	-0.6%	-2.1%	-0.1%	-0.7%
Global Macro	*N*	178	181	181	184	210
	Δ*Risk*	3.28	0.98	0.10	-0.72	-3.30
	Δ *Cash Flows(in $ Mil.)*	-3.88	-3.26	-3.53	-1.18	-13.04
	Δ *Cash Flows(in %)*	-3.0%	1.0%	-0.2%	2.5%	-0.9%
Long/Short Equity Hedge	*N*	1379	1241	1305	1336	1390
	Δ*Risk*	3.80	1.11	0.11	-0.79	-3.21
	Δ *Cash Flows(in $ Mil.)*	-0.47	-0.84	-0.80	-1.01	-0.89
	Δ *Cash Flows(in %)*	-0.7%	-0.3%	0.5%	-0.7%	1.8%

Table 2.7 (continued)

		1	2	3	4	5
Managed Futures	*N*	470	443	432	425	450
	Δ*Risk*	4.64	1.50	0.24	-0.96	-3.94
	Δ *Cash Flows(in $ Mil.)*	-1.16	-1.49	-1.46	-2.32	-1.01
	Δ *Cash Flows(in %)*	-0.8%	-1.2%	0.6%	0.3%	2.5%
Multi-Strategy	*N*	253	254	246	212	249
	Δ*Risk*	2.84	0.90	0.31	-0.25	-1.92
	Δ *Cash Flows(in $ Mil.)*	1.19	-0.08	-2.65	-4.17	1.36
	Δ *Cash Flows(in %)*	1.2%	-1.2%	0.3%	0.2%	-1.7%

Table 2.8 Multivariate Regression Analyses Using Alternative Risk-Shifting Measures and Added Control for Size

This table reports the outputs of the following OLS regression model:

$$\Delta\sigma_{i,t}^{j,TE} = \alpha + \beta_1 \cdot Rank_{i,t} (+\beta_2 \cdot AbsIncentive_{i,t}) + \beta_3 \cdot AbsIncentive_{i,t}^{+} + \beta_4 \cdot AbsIncentive_{i,t}^{-}$$
$$+\beta_5 \cdot AbsIncentive_{i,t}^{+} \cdot I^{HWM} + \beta_6 \cdot AbsIncentive_{i,t}^{-} \cdot I^{HWM} + \gamma_1 \cdot Vix_t + \gamma_2 \cdot \Delta Vix_t + \gamma_3 \cdot \sigma_t^{Index_j} \cdot I^j$$
$$+\gamma_4 \cdot \Delta\sigma_t^{Index_j} \cdot I^j + \gamma_5 \cdot \sigma_{1,i,t} + \gamma_6 \cdot \Delta\log(AUM) + \sum_k \delta_k YearDummy_k + \sum_l \lambda_l StyleDummy_l + \varepsilon_{i,t}$$

The dependent variable, $\sigma_{i,t}^{j,TE}$, is the change in tracking error of individual hedge funds with respect to the hedge fund index returns of the same strategy between the first and second six months in a calendar year. $Rank_{i,t}$ is the percentile of performance ranking of a hedge fund relative to strategy peers at mid-year, 0% representing bottom performers and 100% top performers. AbsIncentive is defined as Moneyness*Icentive Fee. Its positive and negative parts are also included in Model (4). Two interaction terms of AbsIncentive with HWM provision dummy are introduced in Model (5).

Control variables include Vix_t, the contemporary VIX Index average, ΔVix_t, the semi-annual change in it, $\sigma^{Index_j} \cdot I^{Index_j}$, the first six-month standard deviation of Credit Suisse Tremont Hedge Fund Indices of 10 risk strategies[3], $\Delta\sigma^{Index_j} \cdot I^{Index_j}$, the semi-annual change in it, and $\sigma_{i,1}$, the first six-month standard deviation of individual hedge funds. $\log(\Delta AUM)$ is the logarithm of the change in AUM between year halves.

These tests correct for heteroscedasticity in residual errors and diagnostic analyses do not detect mutlilinearity and serial correlation. *, ** and *** indicate statistical significance at 10%, 5% and 1% levels, respectively. All regressions control for the fixed effects of years and hedge fund strategies.

The hurdle rate is set to the three-month T-bill rate throughout this table. Figures in parentheses are t-values.

[3] With the only exception of Fund of Hedge Funds, for which the TASS Fund of Funds Universe Average is used.

	α	β_1	β_2	β_3	β_4	β_5	β_6	γ_1	γ_2	γ_3	γ_4	γ_5	γ_6	*Adj.* R^2	*DF.*
Model (1)	1.39** (2.57)	-0.44*** (-8.04)						-0.05 (-1.31)	0.28* (1.65)	0.31** (15.98)	-0.29** (-22.57)	-0.40*** (-69.72)	-0.25*** (-6.20)	23.40%	21996
Model (2)	1.23** (2.29)		-0.06*** (-11.34)					-0.06 (-1.49)	0.30** (2.17)	0.31** (16.34)	-0.29*** (-22.59)	-0.40*** (-69.54)	-0.22*** (-5.66)	23.62%	21996
Model (3)	1.29** (2.41)	-0.14* (-2.12)	-0.05*** (-8.26)					-0.06 (-1.48)	0.29** (2.11)	0.31** (16.29)	-0.29*** (-22.58)	-0.40*** (-69.47)	-0.20*** (-5.07)	23.63%	21995
Model (4)	1.10** (2.07)	-0.16** (-2.48)		0.06*** (7.28)	-0.25*** (-21.41)			-0.05 (-1.20)	0.26* (1.90)	0.34*** (17.87)	-0.30*** (-22.95)	-0.46*** (-71.98)	-0.20*** (-5.08)	25.02%	21994
Model (5)	1.10** (2.06)	-0.14* (-2.02)		0.04*** (4.02)	-0.31*** (-14.01)	0.03*** (2.76)	0.07*** (3.2)	-0.05 (-1.27)	0.28** (2.09)	0.34*** (17.98)	-0.30*** (-23.01)	-0.46*** (-71.46)	-0.21*** (-5.11)	25.08%	21992

Table 2.9 Sorted Portfolios by Relative Performance

This table reports the change in risk, cumulative return and moneyness for 5 equally-weight hedge fund portfolios in each risk strategy. Portfolios are formed by ranking each individual hedge fund's performance within a calendar year with strategy peers. Portfolio 1 contains bottom performers and Portfolio 5 contains top performers for each risk strategy. The moneyness of each portfolio is estimated by assuming the hurdle rate is 4%.

		1	**2**	**3**	**4**	**5**
Convertible Arbitrage	Δ*Risk*	0.13	0.22	0.29	0.45	0.35
	Return	-1.49	2.25	4.30	6.56	14.47
	Moneyness	-0.09	-0.05	-0.03	-0.01	0.08
Dedicated Short Bias	Δ*Risk*	0.07	0.90	1.19	0.97	-0.03
	Return	-12.32	-4.18	-0.05	4.43	14.23
	Moneyness	-0.29	-0.20	-0.20	-0.18	0.00
Emerging Markets	Δ*Risk*	0.54	0.51	0.64	0.49	-0.28
	Return	-9.43	1.02	6.41	13.20	33.16
	Moneyness	-0.18	-0.09	-0.03	0.05	0.22
Equity Market Neutral	Δ*Risk*	0.12	0.25	0.14	0.10	-0.10
	Return	-3.34	1.54	4.01	6.82	13.99
	Moneyness	-0.11	-0.06	-0.04	-0.01	0.08
Event Driven	Δ*Risk*	0.40	0.39	0.42	0.34	-0.15
	Return	-1.39	3.17	5.41	8.16	18.51
	Moneyness	-0.09	-0.05	-0.02	0.01	0.12
Fixed Income Arbitrage	Δ*Risk*	0.72	0.58	0.38	0.53	0.14
	Return	-3.21	2.32	4.27	6.36	13.22
	Moneyness	-0.11	-0.06	-0.04	-0.01	0.06
Fund of Hedge Funds	Δ*Risk*	0.19	0.19	0.27	0.27	0.11
	Return	-2.74	2.07	3.83	5.54	10.94
	Moneyness	-0.10	-0.06	-0.04	-0.02	0.03
Global Macro	Δ*Risk*	0.26	0.44	0.38	0.02	-0.74
	Return	-8.69	-0.55	3.16	7.42	18.06
	Moneyness	-0.17	-0.08	-0.05	0.00	0.12
Long/Short Equity Hedge	Δ*Risk*	0.38	0.38	0.32	0.16	-0.19
	Return	-8.03	1.34	5.41	9.85	23.05
	Moneyness	-0.17	-0.07	-0.03	0.02	0.16
Managed Futures	Δ*Risk*	0.98	0.59	0.32	0.04	-0.30
	Return	-10.73	-1.16	3.51	8.60	22.51
	Moneyness	-0.18	-0.09	-0.05	0.01	0.17
Multi-Strategy	Δ*Risk*	0.45	0.35	0.49	0.45	0.14
	Return	-4.57	2.29	4.43	7.29	16.24
	Moneyness	-0.13	-0.06	-0.03	0.00	0.09

CHAPTER 3

RISK-SHIFTING, CONTRACTUAL INCENTIVES AND ADVERSE SELECTION OF HEDGE FUND MANAGERS

3.1 Introduction

The theory of contracts, a strand of the agency theory, suggests that when an agent's effort is not fully observable to the principal and when there is much randomness in the production process, it is better for the principal to present the agent a compensation scheme that shares both profits and production risks, than providing him with a fixed amount of pay. This view can, at least partly, explain the prevailing fee structure of hedge fund managers.Unlike their mutual fund peers, whose main source of income, the management fee, is based on the size of the capital pool under management, hedge fund managers have a more mixed fee contract. They do not only charge the flat management fee to compensate trading costs and overhead costs, most, if not all hedge fund managers, can also harvest a non-trivial portion of trading in excess of a pre-set active investment benchmark.[1]

Defined as private investment vehicles and at the cost of being forbidden from public ad-

[1]The most popular hedge fund sharing rule used to be 2/20, 2% management fees and 20% incentive fees. Recent years, especially after the 2008 financial crisis, have witnessed a trend of shrinking the 2/20 structure to 1/10 or 1.5/10.

vertisement, hedge funds, on the other hand, enjoy very loose regulatory oversight and very limited disclosure obligation. While during and after the 2008 financial crisis, the hedge fund industry has been increasingly scrutinized and questioned on their role played in the crisis, many hedge fund managers have argued that the lack of informational transparency to outsiders and even to own investors is in the interest of protecting their proprietary trading strategies .[2] From the viewpoint of the agency theory, the incentive contracts specific to hedge fund managers, are such designed to reward asset managers for their proprietary trading skills and also to share production uncertainty between investors and managers.

The positive relation between incentive contracts and investment alphas has been well documented in hedge fund literature. In this paper, we are dedicated to examining whether such incentive contracts also function well regarding hedge fund manager intra-year risk shifting decisions.

We first use factor models to explain the variability of hedge fund monthly returns and then utilize optimal change-point regressions to capture intra-year risk dynamics of hedge fund managers. With some bootstrapping technique, we are then able to identify a subset of hedge fund managers that statistically significantly change their risk exposures during a calendar year. Next, we rank those risk-shifting hedge fund managers by their subsequent risk-adjusted performance after changing risk and categorize each manager into 'informed', 'uninformed' or 'misinformed' groups.

We are most interested in detecting the difference of risk shifting behavior in response to a hedge fund manager's own incentive contract among each group. Multivariate panel regression results show that 'informed' hedge fund managers exhibit the least sensitivity of risk shifting to their incentive contracts, while 'misinformed' hedge fund managers exhibit the most aggressive risk taking and risk shifting behavior in response to personal compensation. These results imply the problem of 'adverse selection' in hedge fund in-

[2] Glode and Green (2011) in their theoretical model describes a setting in which hedge fund managers sacrifice trading profits to avoid information spillovers that may lead to increased competition and therefore deteriorated returns.

dustry, i.e., incentive contracts induce the strongest risk taking from the least informed or least skilled hedge fund managers, whose risk-shifting decisions ex post result in the most undesired risk-adjusted returns for investors. We also find that the three groups of risk shifting managers respond differently to incentive contracts in changing their total, beta and idiosyncratic risks.

According to the agency theory, 'adverse selection' takes place when there exists severe asymmetry of information. We then reexamine this problem among a collection of hedge funds that refutably suffer the least asymmetry of information—funds of hedge funds, and find that the 'adverse selection' problem is much less evident.

Last, we investigate whether the HWM(hereafter HWM), a loss carry-forward provision in the incentive contract of many hedge fund managers, plays a positive role in mitigating excessive risk taking and aligning interests. We conclude from empirical results that its influence is limited.

The outline of the rest of this paper is as follows. Section 2 reviews existing literature. Section 3 describes the hedge fund data retrieved from the Lipper TASS database. Section 4 details the optimal change-point regression methodology for identifying risk shifting hedge funds. Section 5 provide evidence of the problem of 'adverse selection'. In Section 6, we conduct robustness checks and Section 7 concludes.

3.2 Literature Review

Our paper is related to existing literature along the following dimensions.

3.2.1 Hedge Fund Performance and Incentive Contracts

A rich body of research has related the superior performance the hedge fund industry has delivered in recent decades[3] to its incentive contracts for managers, for example,

[3]However, Fung, Hsieh, Naik and Ramadorai (2008) find that the average funds of hedge funds only deliver alphas during 1998-2000.

Liang (1999), Ackermann, McEnally and Ravenscraft (1999) and Agarwal, Daniel and Naik (2009). The literature also documents that other contractual factors attribute to the alpha production of hedge funds. For example, Aragon and Qian (2007) study HWM in an informational setting where the manager quality is unknown to investors. They find that funds imposing liquidity constraints are more likely to have HWMs to reduce risk of investor-driven liquidation and also, hedge funds with HTM have higher survival rate. Aragon (2007) find significant share illiquidity premium associated with redemption restrictions.

3.2.2 Hedge Fund Risk Dynamics

The hedge fund literature is also growing on evidence that hedge funds have time-varying risk exposures and on innovative methodologies that capture the risk dynamics. For example, Fung and Hsieh (1997) provide empirical evidence that hedge funds follow dynamic trading strategies which cannot be detected by conventional risk factors that explain mutual fund returns well. Fung and Hsieh (2004) further propose a seven-factor model suitable for explaining dynamic risk factor loadings of hedge funds. Agarwal and Naik (2004) find nonlinearity in risk factor exposures and significant tail risk. Fung, Hsieh, Naik and Ramadorai (2008) study hedge fund risk exposures in three sub-periods and document a significant structural change in risk dynamics. Patton and Ramadorai (2010) propose using high frequency conditional information to identify hedge fund risk dynamics and they find that the main drivers for risk change are cost of leverage, carry trade returns and the recent equity market index performance. Bollen and Whaley (2009) compare two empirical methodologies of capturing hedge fund risk shifting and emphasize the importance of accounting for hedge fund risk dynamics.

3.2.3 Risk Taking and Risk Shifting Behaviors of Hedge Fund and Mutual Fund Managers

Our research is also related to literature of asset managers' incentives and performance consequences of risk taking and risk shifting. Kempf, Ruenzi and Thiele (2009) find that the risk taking behaviors of mutual fund managers vary depending on whether the 'employment risk incentives' or the 'compensation incentives' predominate in a particular year. Massa and Patgiri (2009) find evidence that high-incentive mutual fund contracts lead to higher risk taking, higher risk-adjusted performance and persistence in out-performance though they also reduce a fund's survival probability. Brown, Harlow and Starks (1996) address that one reason for mutual fund managers to shift risk is the incentives to play 'tournament games'. Chevalier and Ellison (1997) lend empirical evidence to the rationale of risk tournament by finding that the convexity of the flow-performance relationship can explain the increase or decrease in the riskiness of a mutual fund. Brown, Goetzmann and Park (2001) extend the study to hedge fund industry and find that risk shifts in hedge funds and CTAs are associated with relative performance rather than absolute performance. They attribute the finding to career concerns and reputation costs. Clare and Motson (2009) address the tournament behaviors among hedge fund managers and argue that option-like incentives drive managers' risk taking. However, their study shows that the tournament behaviors are dominated by lock-in behaviors, i.e. a successful fund reducing risk. Aragon and Nanda (2009) investigate the same issue and conclude that tournament is prevailing mainly in the incubation period. Chen and Liang (2007)find that self-described market timing hedge funds possess market timing skills at both individual and aggregate levels, especially when the U.S equity market is bearish and volatile. Cao, Chen, Liang and Lo (2009) report that hedge funds capable of timing market liquidity conditions significant outperform peers.

3.2.4 HWM

The use of HWM, a unique loss recovery provision widely adopted by venture capital funds, private equity funds, hedge funds and commodity trading advisors(CTAs), is also discussed in hedge fund literature. Carpenter (2000) theoretically studies option-like incentive contracts and HWM, and finds that the option-like compensation for a fund manager does not strictly lead to greater risk seeking behavior. Goetzmann, Ingersoll and Ross (2003) propose a theoretical model to evaluate the cost of the HWM provision to managers and compute the alpha-generation skill necessary to justify a fund manager's compensation. Hodder and Jackwerth (2007) justify the use of HWM by using a multi-year evaluation to show that a manager's risk taking is more diverse than can be generated by existing one-period models. Panageas and Westerfield (2009) address that spanning a manager's investment horizon can effectively reduce her risk taking despite her risk appetite.

3.3 Data

The hedge fund data used in our empirical study come from the Lipper TASS hedge fund database, one of the leading hedge fund data vendors. Since the hedge fund industry has been historically subject to very light regulation, there are no mandatory reporting standards that hedge fund managers are required to follow. As a result, there exists a collection of well-documented hedge fund database biases that hedge fund researchers need to carefully cope with. For example, hedge fund data may contain only information for funds that are still in operation and lack the information for funds that are already out of business or closed to new investments (referred to as 'survivorship bias'). Hedge fund managers may choose whether to report to data vendors and if so, which vendor(s) to report to at utter discretion (referred to as 'self-selection bias'). After they report to a database, managers can voluntarily provide the data vendor with their track records, where there is no guarantee that the reported historical performance has been audited and validated (referred to as 'back-filling bias'). For more detailed analyses of the impact of these biases, see Brown, Goetzmann and Ibbotson (1999),Fung and Hsieh (2000) and Liang (2000).

In view of this, we impose several screening criteria in selecting our sample in order to minimize the influence of potential biases.

(1) We include both the 'live funds' and 'graveyard funds' reported by TASS in our sample. Our sample only covers Jan. 1994 through Dec. 2008 because 'graveyard funds' were not recorded by Lipper TASS until 1994. Every fund in our sample must be denominated in US dollars, report monthly returns, management fees and incentive fees, and have complete return history for at least one calendar year. These criteria result in a total sample of 8244 hedge funds, of which 3402 are 'live' and 4842 are 'defunct'.

(2) We retrieve the date on which a specific fund is added to TASS database and deem the period between the date of the first reported return and the adding date as the incubation period. If the adding date is missing for a fund, we use the first 18 months to proxy for the incubation period. There are in total 37108 fund years, of which 19161 are during incubation period and 17947 are during non-incubation period.

(3) Hedge fund returns in TASS database are categorized into three groups, gross returns, net returns, and gross returns net of management fees. We use the methodology proposed by Brooks, Clare and Motson (2007) with some minor modification (detailed below in Section 3.2) to generate the gross return series for all hedge funds if only after-fee returns are reported. Brooks, Clare and Motson (2007) point out that the use of net returns tends to underestimate the mean and variation of the "true returns" or the gross returns from a manager's operation.

3.3.1 Measuring Absolute Performance

Since the fee structure of hedge fund managers contains performance fees that allow managers to collect a portion of returns as long as they beat the historical high or previous year's NAV, managers should have additional economic incentives that deviate from that arising from performance relative to other funds. We measure the incentives from 'absolute performance' by two means, first, whether a hedge fund is currently under the HWM, and second, the 'moneyness' of a hedge fund if we consider the performance fee as a call option with the HWM being the strike.

Both measures involve an estimation of the HWM, which is a difficult task because the HWM of a hedge fund may not be unique since a hedge fund can have multiple share classes or multiple investors who enter the fund at different times. Based on a simplifying assumption that a hedge fund at any time can have only one HWM, we measure its absolute performance as follows,

$$Moneyness_{i,t} = \frac{NAV_{i,t}}{NAV^*_{i,t}} - 1 \tag{3.1}$$

$NAV^*_{i,t}$ is the mininum NAV of a hedge fund that allows the manager to charge performance fees. Specifically, it is the historical high of NAV (HWM) for hedge funds with a HWM and the NAV at previous year-end for hedge funds without a HWM. $NAV^*_{i,t}$ plays a very important role in providing managers with incentives since it is the threshold over which the pay-performance slope (or sensitivity) becomes positive from zero. According to the above definition, a negative moneyness means that the manager needs to make positive returns during the current period before she can charge performance fees. A positive moneyness, on the other hand, means that the manager is able to charge performance fees with current NAV.

3.3.2 Computing HWM and Gross Returns

Similar to Brooks, Clare and Motson (2007), We solve for the HWM and gross return series for each hedge fund that features a HWM recursively following the procedure in Appendix B.[4]

[4]In accordance with most common hedge fund industry practice, we assume that management fees are paid monthly, and performance fees are accrued monthly and paid yearly.

In Table 3.1, we present basic descriptive statistics of the performance and risk of hedge funds over 1994-2008 in our sample. Lipper TASS database categorizes an individual hedge fund into 13 risk styles, namely, Convertible Arbitrage, Dedicated Short Bias, Emerging Markets, Equity Market Neutral, Event Driven, Fixed Income Arbitrage, Fund of Funds, Global Macro, Long/Short Equity Hedge, Managed Futures, Multi-Strategy, Options Strategy and Other Strategies. For each subgroup in Table 3.1, we construct an equally-weighted hedge fund portfolio and report its performance.

In Table 3.2, we report important hedge fund fee contract provisions, such as management fee, incentive fee, whether a hedge fund has HWM, whether a hedge fund permits management to invest own capital, whether a hedge fund sets a lock-up period, etc. In Panel B, we also estimate the length of time a hedge fund is under the water, accrued incentive fees and moneyness defined in Equation(3.1), in order to depict a rough picture of the significance and magnitude of economic incentives resulting from absolute performance.[5] It is noteworthy that on average a hedge fund stays for quite a long time, 6.5 months under water in a calendar year. The average monthly accrued incentive fees amount to 0.41% of the asset under management, which outweighs the average monthly management fee that equals about $1.5\% \div 12 \approx 0.125\%$. Besides, the average moneyness is slightly higher than zero, implying that the call option of the manager's incentive fees is approximately 'at the money', where the vega reaches its maximum and the value of the call is most sensitive to the underlying's volatility.

3.4 Intra-year Systematic Risk Shifting

In this section, we employ optimal changing-point regressions to identify systematic risk shifting of hedge fund managers during a calendar year.

[5] we assume an annual hurdle rate of 4% in computation, since Lipper TASS does not provide uniform reports of this variable.

3.4.1 Factor Analyses and BIC

In order to identify the risk factors to which a particular hedge fund is exposed within a calendar year, we first apply three-factor OLS regression models to the monthly returns for each hedge fund. Risk factor candidates include the three Fama-French factors, namely, MKTXS, the excess return of the CRSP value-weighted index, SMB, the size factor and HML, the value factor, as well as the seven Fung and Hsieh asset-based style factors that are, D10YR, the change in the 10-year treasury yield, DSPRD, the change in the spread between BAA yield and 10-year treasury yield[6], PTFSBD, primitive trend follower strategy bond, PTFSFX, primitive trend follower strategy currency, PTFSCOM, primitive trend follower strategy commodity, PTFSIR, primitive trend follower strategy interest rate, and PTFSSTK, primitive trend follower strategy stock .[7]

There are 28974 fund-years in the sample and 120 possible combinations of three factors out of the 10 candidates. For each fund-year, we run a three-factor OLS regression model and repeat this procedure for 120 times with all different combinations of three risk factors . We then select the set of three factors that results in the lowest Bayesian Information Criterion (BIC) and therefore the highest adjusted R^2 for each fund-year.

Table 3.3 reports the summary statistics of the three-factor models within each risk strategy. On average, the optimal three-factor model is able to explain 63% of the variability in the time-series of individual hedge fund monthly returns in a calendar year. Table 3.3 also provides an overview of the explanatory power that each risk factor has on different hedge fund strategies . For example, MKTXS, the U.S equity market index, is an important factor for 12 out of 13 strategies with no surprise. PTFSIR, the short-term interest rate factor, also has important explanatory power for 8 out of 13 strategies. One reason is that the performance of those hedge fund strategies that employ heavy financial leverage is sensitive to the change in short-term borrowing costs that is reflected in PTFSIR.

[6]D10YR and DSPRD are downloaded from the U.S Federal Reserves website.

[7]The five trend follower factors are available at David Hsiehs website.

3.4.2 Optimal Change-point Regressions

In last section, we have identified the three most important risk factors in explaining the time-series of monthly returns in a year for each hedge fund. Now we proceed to investigate whether a particular hedge fund changes its risk exposure during a year by performing optimal changing-point regressions, with the assumption that a hedge fund manager in a year sticks to the original risk strategy characterized by the risk factors she chooses in the beginning of a year and only changes factor loadings subsequently. Therefore, she does not shift from one risk strategy (a set of risk factors) to another . The optimal change-point regression model is employed for this purpose since it can be used to test for parameter consistency against the alternative of possible structural changes at unknown times. Therefore, if a hedge fund manager significantly changes her factor loadings during a year, the optimal change-point regression should be able to unveil the timing and magnitude of the shift in risk taking. Following Bollen and Whaley (2009), we allow the presence of one single change-point for individual hedge funds during a year . The three-factor model we use to capture the intra-year risk dynamics of hedge fund is as follows,

$$r_{i,t} = \begin{cases} \alpha_i + \sum_{j=1}^{3} \beta_{i,j} f_{i,j} + \varepsilon_{i,j} & \text{when } t \leq \tau_i, \\ \alpha_i + \alpha_i^0 + \sum_{j=1}^{3} (\beta_{i,j} + \beta_{i,j}^0) f_{i,j} + \varepsilon_{i,j} & \text{when } t > \tau_i. \end{cases} \tag{3.2}$$

where $r_{i,t}$ is the return on hedge fund i in month t; $f_{i,j}$ is the return on hedge fund i's risk factor in month t and τ_i is the change-point for hedge fund i.

Whether a hedge fund manager i changes risk exposure during a year can thus be tested via

$$H_0^i : \alpha_i^0 = 0 \text{ and } \beta_{i,j}^0 = 0, \text{for } j = 1,2,3 \tag{3.3}$$

The optimal change-point regression model searches across all possible change-points during a year. Since we adopt a three-factor model, possible dates for a hedge fund manager to change risk exposures are then the end of May, June and July.

Andrews, Lee and Ploberger (1996) derive the F-statistic for testing the null hypothesis for change-point , when the error variances are unknown as below,

$$F(\pi) = \frac{[Q^* - Q(\pi)](T - 2v)}{Q(\pi)v} \tag{3.4}$$

Where Q^* is the sum of squared errors for the whole time period (the unrestricted model) and $Q(\pi)$ is the sum of squared errors when the risk exposures before and post date are allowed to differ. T is the total months of a year and $v-1$ is the number of risk factors. In our three-factor model, $v = 4$.

The F-statistics of all possible π are then calculated and an Avg-F statistic, assuming that changes in risk exposures are small, can be then computed as follows,

$$\text{Avg-F} = \sum_{\pi \subset \Pi} F(\pi)J(\pi) \tag{3.5}$$

Where $J(\pi)$ is a weighting function and since we have no specific reason that any change-points are more likely than others, each change-point receives equal weights in computing Avg-F statistic.

3.4.3 Bootstrapped Critical Values

As pointed out in Andrews, Lee and Ploberger (1996), the critical value for the Avg-F introduced above is model specific and data specific. Empirical critical values need to be computed for the purpose of testing the statistic significance of risk exposure changes. We obey the following procedure in generating bootstrapped hedge fund returns.

1. For each hedge fund that has a full calendar year of reported monthly returns, we perform an OLS regression on the three factors that has the lowest BIC (the highest Adjusted R^2), and save the constant risk factor loadings and residual terms.

2. For each bootstrapped hedge fund return series of a year, we draw factor returns

during that year with replacement, multiply the factor returns by the OLS estimates of factor loadings, and add original residual terms as follows,

$$r_{i,t} = \hat{\alpha}_i + \sum_{j=1}^{3} \hat{\beta}_{i,j} f_{i,j}^{(b)} + \hat{\varepsilon}_{i,j} \tag{3.6}$$

3. For each fund year, we simulate 1000 such return series and for each return series, we compute the Avg-F statistic in (4).

4. Since all factor returns are drawn randomly with replacement and the original residual terms are reserved, such bootstrapping should provide an empirical distribution of the Avg-F under the null hypothesis of no change in risk exposures.

5. The 100th largest test statistic therefore gives the empirical critical value at 10% significance level. We then compare the Avg-F from the original model with its bootstrapped critical value for each fund year. If the original Avg-F is higher then the bootstrapped one, then we reject the null hypothesis that this hedge fund does not change risk exposure in a year.

Out of 28970 complete fund years (6176 funds during Jan. 1994 and Dec. 2008), we find 1963 fund years (1572 funds during Jan. 1994 and Dec. 2008) that change their risk exposures at 10% significant level.

3.5 Managerial Incentives and Adverse Selection

Hedge fund managers change risk exposures for varies reasons. For example, skillful or informed managers may alter their risk factor loadings in response to changing market conditions and produce alpha, as found in Chen and Liang (2007) and Cao, Chen, Liang and Lo (2009). On the other hand, asset managers may also shift risk exposures due to ill-aligned interests between investors and the manager, as addressed in Brown, Harlow and Starks (1996) and Brown, Goetzmann and Park (2001). Huang, Sialm and Zhang (2010) find that the most actively risk-shifting mutual funds have the poorest post-shifting performance and they attribute this results to ill-motivated trading activities and agency problems.

3.5.1 Informed, Uninformed and Misinformed Hedge Fund Managers

From a risk-averse investor's viewpoint, a fund manager's risk-shifting decisions, if any, should reflect the best interest of investors and result in improved risk-adjusted returns. Among the set of risk shifting funds we have identified in last section, we categorize their fund managers into three groups, informed, uninformed and misinformed, according to the change in the Shape Ratio before and after the shift of risk exposures.

Table 3.4 lists the results. It can be observed from Panel A that 'informed' hedge fund managers on aggregate reduce their total risk and the change in accumulated return after shifting (14.19%) is highest among the three groups. As a result, 'informed' hedge fund managers improve the Sharpe Ratio by 6.86 on average and create value for investors via their risk shifting decisions.

'Uninformed' hedge fund managers on aggregate do not improve their risk-adjusted returns via their risk shifting decisions, as indicated by the barely changed Sharpe Ratio. On average, this group of managers moderately increases their total risk by about 0.36% monthly but does not result in significant boost in returns.

'Misinformed' hedge fund managers, on the other hand, aggressively increase their portfolio risk by 1.30% monthly, however, perform poorly after the risk shifting and therefore result in deteriorated Sharpe Ratio. The group-wise differences on the change in the Sharpe Ratio, the change in accumulated returns, and the change in standard deviation before and after risk shifting are all significant at 1% level, showing that the performance and risk-shifting characteristics between groups are both statistically and economically distinct.

Further, we in Panel B examine the differences of fund characteristics between groups, such as fund age, assets under management (AUM), the percentage of incentive fees and management fees, whether a fund features a HWM, whether a fund allows managers to invest own capital, and whether a fund utilizes financial leverage. Panel B demonstrates that unlike the performance and risk shifting characteristics, there is merely any statistically significant difference between groups on fund characteristics, except that 'misinformed' hedge fund managers on average are 0.7 years shorter in tenure than 'informed' and 'uninformed' hedge fund managers. The results in Panel B show that it is not likely that the categorization of 'informed', 'uninformed' and 'misinformed' hedge fund managers is due to its high correlation to some fund characteristics.

3.5.2 Different Risk Appetites and Adverse Selection

In this section, we use multivariate regression models to investigate how each group of hedge fund managers makes risk shifting decisions differently in response to their own incentive contracts, changing market conditions and their style peers risk shifting decisions.

First, we run the following specification,

$$\begin{aligned}\Delta\sigma_{i,j,t} = {} & \alpha + \beta_1 \cdot Money^{+}_{i,t} + \beta_2 \cdot Money^{-}_{i,t} + \beta_3 \cdot Money^{+}_{i,t} \cdot \boldsymbol{I}^{HWM}_i + \beta_4 \cdot Money^{-}_{i,t} \cdot \boldsymbol{I}^{HWM}_i \\ & + \gamma_1 \cdot Vix_{t-1} + \gamma_2 \cdot \Delta Vix_t + \gamma_3 \cdot \sigma^{Index_j}_{t-1} \cdot \boldsymbol{I}^j + \gamma_4 \cdot \Delta\sigma^{Index_j}_t \cdot \boldsymbol{I}^j + \gamma_5 \cdot \sigma_{i,t-1} + \gamma_6 \cdot R_{i,t-1} \\ & + \gamma_7 \cdot \boldsymbol{I}^{HWM}_i + \sum_k \delta_k \cdot YearDummy_k + \sum_l \lambda_l \cdot StyleDummy_l + \varepsilon_{i,t}\end{aligned} \tag{3.7}$$

The dependent variable is the change in standard deviation of a hedge fund before and after it changes risk exposures. The moneyness of a hedge fund manager's incentive contract at time t is defined in Equation(3.1) Moneyness serves a proxy for managerial incentives from the contract, and β_1 captures the relation between a fund managers risk shifting behavior and her fee incentives when moneyness is positive, that is, the fund is operating above the water mark). β_2 captures the relation when moneyness is negative. β_3 and β_4 capture the interactive effect between moneyness and whether a hedge fund uses a HWM. Vix and ΔVix proxy for the U.S equity market volatility and its change. $\sigma^{Index_j}_{t-1} \cdot \boldsymbol{I}^j$

and $\Delta\sigma_t^{Index_j} \cdot \boldsymbol{I}^j$ control for the risk and change in risk of the same strategy hedge fund index and $\sigma_{i,t-1}$ controls for individual fund risk taking before shifting. $R_{i,t-1}$ is fund is accumulated return prior to risk shifting.

OLS estimates for all three hedge fund manager groups are reported in Table 3.5. Each group demonstrates very distinctive risk-shifting behavior related to incentive contracts. The risk shifting of 'informed' managers does not seem to be related to either moneyness or the HWM provision. To the opposite, 'misinformed' managers aggressively shift risk when they have found themselves below the water. 'Uninformed' managers risk shifting behavior is moderate in response to their moneyness compared to the other two groups and they only respond to the upside of moneyness. It is also worth noticing that the 'uninformed' managers, unlike the other two groups, positively and significantly respond to the risk shifting decisions of peer managers in the same strategy because the coefficients of index risk level and the change in index risk level are both positive and statistically significance.

The results in Table 3.5 reflect agency problems that induce adverse selection. Namely, the prevailing hedge fund incentive contracts encourage the least informed managers to shift risk in the most aggressive manner, while this group of managers is least sophisticated in risk management and alpha-producing.

3.5.3 Beta Risk Shifting vs. Idiosyncratic Risk Shifting

In this section, we further examine how these three groups of hedge fund managers make beta risk shifting and idiosyncratic risk shifting decisions in response to their incentive contracts. We rerun the regression model in Equation(3.7), replacing the dependent variables with beta risk measure and unsystematic risk measure, respectively.

The beta risk regression model is as follows,

$$
\begin{aligned}
\Delta\sigma^{beta}_{i,j,t} = {} & \alpha + \beta_1 \cdot Money^{+}_{i,t} + \beta_2 \cdot Money^{-}_{i,t} + \beta_3 \cdot Money^{+}_{i,t} \cdot \boldsymbol{I}^{HWM}_i + \beta_4 \cdot Money^{-}_{i,t} \cdot \boldsymbol{I}^{HWM}_i \\
& + \gamma_1 \cdot Vix_{t-1} + \gamma_2 \cdot \Delta Vix_t + \gamma_3 \cdot \sigma^{Index_j}_{t-1} \cdot \boldsymbol{I}^j + \gamma_4 \cdot \Delta\sigma^{Index_j}_t \cdot \boldsymbol{I}^j + \gamma_5 \cdot \sigma_{i,t-1} + \gamma_6 \cdot R_{i,t-1} \\
& + \gamma_7 \cdot \boldsymbol{I}^{HWM}_i + \sum_k \delta_k \cdot YearDummy_k + \sum_l \lambda_l \cdot StyleDummy_l + \varepsilon_{i,t}
\end{aligned}
\tag{3.8}
$$

where

$$
\Delta\sigma^{beta}_{i,j,t} = \sqrt{\frac{SSM_{i,j,t}}{k}} - \sqrt{\frac{SSM_{i,j,t-1}}{k}}
$$

in which *SSM* is the sum of squares about the mean from the three-factor model for hedge fund i that has the lowest BIC. k is the number of explanatory variables (three in our models).

Table 3.6 reports the estimates. 'Informed' hedge fund managers do not exhibit significant risk shifting behaviors in response to the variables related to their incentive contracts. 'Uninformed' hedge fund managers respond to Moneyness when it is positive. 'Misinformed' hedge fund managers aggressively increase beta risk when they are below the water. HWM provision does not function in restraining managers from excessive beta risk shifting, since no interactive term is positive and significant.

The idiosyncratic risk regression model is as follows,

$$
\begin{aligned}
\Delta\sigma^{alpha}_{i,j,t} = {} & \alpha + \beta_1 \cdot Money^{+}_{i,t} + \beta_2 \cdot Money^{-}_{i,t} + \beta_3 \cdot Money^{+}_{i,t} \cdot \boldsymbol{I}^{HWM}_i + \beta_4 \cdot Money^{-}_{i,t} \cdot \boldsymbol{I}^{HWM}_i \\
& + \gamma_1 \cdot Vix_{t-1} + \gamma_2 \cdot \Delta Vix_t + \gamma_3 \cdot \sigma^{Index_j}_{t-1} \cdot \boldsymbol{I}^j + \gamma_4 \cdot \Delta\sigma^{Index_j}_t \cdot \boldsymbol{I}^j + \gamma_5 \cdot \sigma_{i,t-1} + \gamma_6 \cdot R_{i,t-1} \\
& + \gamma_7 \cdot \boldsymbol{I}^{HWM}_i + \sum_k \delta_k \cdot YearDummy_k + \sum_l \lambda_l \cdot StyleDummy_l + \varepsilon_{i,t}
\end{aligned}
\tag{3.9}
$$

where

$$\Delta\sigma_{i,j,t}^{alpha} = \sqrt{\frac{SSE_{i,j,t}}{n-k-1}} - \sqrt{\frac{SSE_{i,j,t-1}}{n-k-1}}$$

in which *SSE* is the sum of squared errors from the three-factor model for hedge fund i that has the lowest BIC. k is the number of explanatory variables (three in our models) and n is the total number of observations in each time-series regression model.

Table 3.7 reports the estimates. All three groups of managers show significant sensitivity of risk shifting to incentive contracts. Moreover, the incentive to increase risk is stronger when a manager is underperforming than when she is outperforming her own HWM. Among the three groups, 'misinformed' managers again, exhibit the most aggressive manner of risk shifting in response to both downside and upside of Moneyness. HWM works well in reducing "informed' and 'misinformed' managers' risk taking since the interactive term of for these two groups is negative and significant, indicating that all else equal, managers that have HWM in these two groups tend to take less risk than managers that do not in response to underperformance.

To summarize the findings of this section, 'informed', 'uninformed' and 'misinformed' managers exhibit very distinct risk shifting behaviors in response to their personal compensation related to incentive contracts. 'Misinformed' managers are the most aggressive in increasing both beta and alpha risk. On the other hand, 'informed' managers do not significant associate their risk shifting decisions to incentive contracts and 'uninformed' managers respond moderately. The total risk shifting behavior is similar to the beta risk shifting behavior for all three groups. Regarding alpha risk shifting, all three groups exhibit strong sensitivity of risk shifting to incentive contracts. Again, 'uninformed' managers have the highest sensitivity. HWM, designed to align interests between managers and investors, only imposes limited influence on reducing excessive risk taking.

3.5.4 Remedy for Adverse Selection and Funds of Hedge Funds

The presence of adverse selection stems from the asymmetry of information between managers and investors. The problem is further worsened by the lack of transparency problem increasingly scrutinized in recent years on the whole hedge fund industry. Funds of Hedge Funds, as suggested in the literature (e.g. see Fung and Hsieh (2000), Brown, Goetzmann and Liang (2003) and Fung, Hsieh, Naik and Ramadorai (2008)) serve many functions, such as manager selection, portfolio construction, risk management, monitoring and due diligence for investors who prefer the delegated approach of accessing hedge funds.

In Table 3.8, we examine whether the adverse selection problem can be mitigated when the regression model is performed only on fund of hedge funds. It shows that compared to previous results, the three groups exhibit much less risk taking in response to incentive contracts.

3.6 Robustness Tests

3.6.1 Risk Shifting vs. Non-shifting Funds

The above results should not be applied to an extended group of hedge funds if the set of risk shifting funds lacks representativeness for the whole hedge fund family. In this section, we compare shifting funds to non-shifting funds and investigate whether the two groups differ from each other on age, size, risk strategy, and other fund characteristics.

Figure 1 compares the distribution of risk style for risk shifting funds to that for the whole hedge fund family. It shows that risk shifting is not concentrated on a risk strategies, but rather widespread among the hedge fund family.

Figure 2 reports the distribution of calendar years in the period of 1994-2008. It shows that the distribution of shifting funds does not differ much from that of non-shifting funds except for 2005. Table 3.9 tabulates the difference between shifting and non-shifting funds.

It shows that these two groups do no significant differ from each other on either performance or fund characteristics.

3.6.2 Alternative Risk-adjusted Performance Measures and Categorization

In order to ensure the robustness of our results in Table 3.5-3.7, we use different risk-adjusted performance measures other than the Sharpe Ratio in identifying informed, uninformed and misinformed hedge fund managers as follows,

(1) A pseudo-Treynor Ratio, $\frac{r_i - r_f}{\sqrt{SSM/k}}$, and

(2) The Information Ratio $\frac{r_i - r_b}{\sqrt{Var(r - r_b)}}$, where r_b, the benchmark return, is the hedge fund index return with the same strategy.

We also rank and divide risk-shifting hedge fund managers into 3, 5 and 6 groups according to their change in risk-adjusted performance and label the top and bottom groups as 'Informed' and 'Misinformed' managers. The group(s) in between is then labelled as 'Uninformed' managers.

Our main results in Table 3.5-3.7 are robust to all combinations of alternative risk-adjusted performance measures and different group numbers. Table 3.10-3.12 report the regression estimates when the pseudo-Treynor Ratio is used and when the group number is five.

3.7 Conclusion

In this paper, we study the risk shifting decisions of hedge fund managers in response to their personal compensation from the incentive contracts. Although documented to be positively associated with superior long term performance, hedge fund incentive contracts do not seem to align interests well between investors and managers, regarding their influence on managers risk taking and shifting behaviors. Namely, given prevailing incentive contracts, the least skillful and informed managers tend to make the most aggressively risk shifting decisions in response to the possibility to charge incentive fees and result in inferior performance consequences.

The finding of the 'Adverse Selection' problem reflects the failure of hedge fund managers to signal their types to potential investors, and the malfunction of incentive contracts in revealing hedge fund managers quality. The results of our research call for better mechanism design for investors to identity managers characteristics, to reduce informational asymmetry and to penalize managers for actions that deviate from the best interest of hedge fund investors.

Table 3.1 Summary Statistics

Table 3.1 presents summary statistics of monthly returns and mid-year risk shifting of equally-weighted hedge fund portfolios and hedge fund indices in each risk strategy over the period of 1994-2008. Both individual hedge fund and hedge fund index data come from the Lipper TASS database. We benchmark each risk group of individual hedge funds with the Credit Suisse/Tremont Hedge Fund Index USD of the corresponding risk strategy, with the only exception of Fund of Hedge Funds, for which we use TASS Fund of Funds Universe Average.

Monthly returns, r, are measured in %. Risk shifting for fund i in calendar year t, σ_{2i}-$\sigma_{1i,}$ is defined as the excess standard deviation of the second half year over the standard deviation of the first half year.

	Individual Hedge Funds					Hedge Fund Indices			
	Number (N)	**Monthly Returns (r)**		**Risk Shifting (σ_{2i}-σ_{1i})**		**Monthly Returns (r)**		**Risk Shifting (σ_{2i}-σ_{1i})**	
		Mean	**Std**	**Mean**	**Std**	**Mean**	**Std**	**Mean**	**Std**
All Funds	7206	0.53	1.23	0.25	2.66	0.73	2.30	0.29	1.52
Convertible Arbitrage	204	0.52	0.64	0.29	1.99	0.46	1.98	0.09	0.94
Dedicated Short Bias	43	0.69	1.46	0.67	4.05	0.05	4.90	0.94	2.12
Emerging Markets	430	0.47	2.00	0.38	4.03	0.65	4.58	0.56	2.19
Equity Market Neutral	367	0.49	0.77	0.10	1.58	0.52	3.18	1.30	4.29
Event Driven	596	0.67	1.17	0.28	2.01	0.78	1.76	0.40	0.89
Fixed Income Arbitrage	302	0.48	1.05	0.47	2.37	0.30	1.73	0.44	0.85
Fund of Hedge Funds	1646	0.27	0.99	0.21	1.73	0.48	1.75	0.17	0.78
Global Macro	367	0.56	1.40	0.07	2.69	1.03	3.05	0.33	0.97
Long/Short Equity Hedge	2168	0.65	1.29	0.21	3.10	0.82	2.95	0.14	1.42
Managed Futures	575	0.78	1.17	0.33	3.38	0.64	3.44	0.20	1.47
Multi-Strategy	508	0.46	1.24	0.38	2.25	0.59	1.58	0.41	0.64

Table 3.2 Hedge Fund Compensation Structure and Fee Incentives

Table 3.2 reports summary statistics of the compensation structure of 7206 hedge funds over the period of 1994-2008. Management Fee and Incentive Fee are reported to Lipper TASS database in percentage of a fund's NAV and excess return, respectively. HWM Dummy equals one when a hedge fund features a High Water Mark provision and zero otherwise.

Also reported in Table II are estimates that measure a hedge fund manager's monetary incentives from fees. Paid-out Incentive Fee measures the fraction of a hedge fund's NAV that the manager charges investors as the incentive fee, assuming the fee is accrued monthly and collected yearly. Mid-Year Moneyness is defined as $NAV^{June}/NAV^{HWM} - 1$[1], considering a hedge fund's manager's incentive fee as a series of European call options with one-year expiration each. Time under High Water is the time length, measured in number of months, before a hedge fund manager is able to accrue the incentive fee during a calendar year. All these three variables are estimated and reported at hurdle rates of 0%, 4% and 8%.

	Min	**25th Pctl**	**Mean**	**75th Pctl**	**Max**	**Std**
Management Fee (in % of NAV annually)	0.00	1.00	1.47	2.00	10.00	0.68
Incentive Fee (in % of excess returns)	0.00	10.00	15.54	20.00	50.00	7.67
HWM Dummy	0.00	0.00	0.61	1.00	1.00	0.49
Paid-out Incentive Fee (in % of NAV annually)						
At hurdle rate= 0%	0.00	0.00	2.54	3.31	114.06	4.53
At hurdle rate= 4%	0.00	0.00	2.12	2.56	113.41	4.39
At hurdle rate= 8%	0.00	0.00	1.75	1.82	112.79	4.26
Mid-Year Moneyness						
At hurdle rate= 0%	-0.86	0.00	0.06	0.10	4.50	0.15
At hurdle rate= 4%	-0.87	-0.04	0.01	0.06	4.33	0.15
At hurdle rate= 8%	-0.87	-0.08	-0.03	0.02	4.18	0.14
Time under High Water (in months per year)						
At hurdle rate= 0%	0.00	0.00	3.32	6.00	12.00	4.26
At hurdle rate= 4%	0.00	3.00	6.48	11.00	12.00	4.25
At hurdle rate= 8%	0.00	6.00	8.72	12.00	12.00	3.71

[1] If a hedge fund has a HWM provision, then NAV^{HWM} equals historical high; otherwise, it equals the closing NAV of the previous year.

Table 3.3 Summary Statistics of Three-Factor Models

Three-factor models are estimated by OLS regressions on monthly returns of hedge funds using a pool of ten risk factors, the three Fama-French factors and the seven Fung and Hsieh asset-based style factors. For each fund-year, the optimal set of three factors that best explain the variability of monthly returns is selected by Bayesian Information Criterion (BIC). Listed are summary statistics within each hedge fund risk strategy. In bold are the top four factors most frequently selected for the optimal three-factor models in each risk strategy. Also reported are the number of hedge funds and the average adjusted R-squared of the optimal three-factor models for each fund within the same risk strategy. Data range from Jan.1994 to Dec.2008.

MKTXS: Excess return of the CRSP value-weighted index

SMB: Fama–French size factor

HML: Fama–French value factor

D10YR: Change in the 10-year treasury yield

DSPRD: Change in the spread between BAA yield and 10-year treasury yield

PTFSBD: Primitive trend follower strategy bond

PTFSFX: Primitive trend follower strategy currency

PTFSCOM: Primitive trend follower strategy commodity

PTFSIR: Primitive trend follower strategy interest rate

PTFSSTK: Primitive trend follower strategy stock

	Percentage of funds with factor exposure										No. of Fund-years	Adj.R^2
Strategy/Factor	MKTXS	SMB	HML	D10YR	DSPRD	PTFSBD	PTFSFX	PTFSCOM	PTFSIR	PTFSSTK		
Convertible Arbitrage	26.8%	**29.4%**	28.7%	**35.6%**	**31.2%**	25.9%	22.3%	28.1%	**43.8%**	28.1%	951	0.54
Dedicated Short Bias	**67.5%**	**35.6%**	**40.7%**	**24.7%**	24.7%	21.1%	17.0%	23.7%	23.2%	21.6%	194	0.77
Emerging Markets	**46.3%**	27.3%	**32.5%**	27.3%	27.0%	25.6%	20.2%	**31.8%**	**37.2%**	24.7%	1767	0.63
Equity Market Neutral	**37.2%**	29.5%	**35.6%**	**33.1%**	28.3%	24.0%	26.4%	25.1%	**33.3%**	27.4%	1210	0.57
Event Driven	**44.8%**	29.6%	**34.1%**	27.0%	**31.9%**	27.6%	23.5%	24.5%	**30.7%**	26.3%	2662	0.61
Fixed Income Arbitrage	**33.8%**	26.5%	28.3%	**37.9%**	**35.4%**	**29.6%**	24.4%	27.7%	27.7%	28.9%	1099	0.56
Fund of Funds	**55.8%**	22.4%	**32.6%**	**29.8%**	27.4%	23.8%	24.9%	24.5%	**37.2%**	21.7%	7088	0.67
Global Macro	**41.2%**	27.3%	**30.4%**	**31.3%**	27.4%	24.2%	29.8%	28.5%	**33.0%**	26.8%	1176	0.59
Long/Short Equity Hedge	**52.7%**	**32.4%**	**35.2%**	26.5%	27.8%	25.2%	21.5%	25.4%	**28.3%**	25.0%	8512	0.66
Managed Futures	**39.8%**	25.8%	24.3%	**34.3%**	25.1%	27.3%	**34.4%**	**35.9%**	29.6%	23.6%	2422	0.58
Multi-Strategy	**46.1%**	25.8%	29.2%	29.2%	**30.8%**	26.3%	25.6%	27.6%	**35.5%**	23.7%	1823	0.61
Options Strategy	33.3%	0.0%	0.0%	0.0%	33.3%	33.3%	33.3%	33.3%	33.3%	**100.0%**	3	0.54
Other	**44.8%**	22.4%	32.8%	26.9%	20.9%	**38.8%**	25.4%	29.9%	22.4%	**35.8%**	67	0.52
All	**48.3%**	27.8%	**32.4%**	**29.4%**	28.4%	25.5%	24.4%	26.8%	**32.6%**	24.5%	28974	0.63

Table 3.4 Comparison between Informed, Uninformed and Misinformed Hedge Fund Managers

Panel A reports the differences of informed, uninformed and misinformed hedge fund managers on the change in performance variables before and after their risk-shifting decisions. Panel B compares the fund characteristics among the three groups of hedge fund managers. T-test significance for the comparisons is also provided.

Panel A Comparison of Mean Performance Variables						
	Informed (1)	Uninformed (2)	Misinformed (3)	(1)-(2)	(2)-(3)	(1)-(3)
Number of Funds	480	960	480			
ΔSharpe Ratio	6.86	0.04	-8.16	6.83***	8.19***	15.02***
ΔStd (%)	-0.27	0.36	1.30	-0.63***	-0.95***	-1.58***
ΔReturn (%)	14.19	-0.25	-16.18	14.44***	15.93***	30.36***
ΔMoneyness	0.09	0.04	0.01	0.05***	0.03**	0.08***
LagReturn(%)	-0.36	3.83	10.88	-4.19***	-7.05***	-11.24***

Panel B Comparison of Mean Fund Characteristics						
	Informed (1)	Uninformed (2)	Misinformed (3)	(1)-(2)	(2)-(3)	(1)-(3)
Age (years)	6.56	6.56	5.86	0.01	0.70***	0.71***
AUM (million dollars)	153.69	163.23	187.68	-9.54	-24.45	-34.00
IFee (%)	15.83	15.00	15.35	0.83	-0.35	0.48
MFee (%)	1.44	1.42	1.42	0.02	0.00	0.03
HighWaterMark (dummy)	0.59	0.57	0.57	0.02	0.00	0.02
Personal Capital (dummy)	0.31	0.37	0.34	-0.06*	0.03	-0.03
Leverage (dummy)	0.58	0.58	0.60	0.00	-0.01	-0.02

*, **, *** indicate a significance level of 10%, 5% and 1%, respectively.

Table 3.5 Total Risk Shifting Behavior of Three Groups of Hedge Fund Managers

This table reports the outputs of the following OLS regression model:

$$\Delta\sigma_{i,t}^{j} = \alpha + \beta_1 \cdot Moneyness_{i,t}^{+} + \beta_2 \cdot Moneyness_{i,t}^{+} \cdot I^{HWM} + \beta_3 \cdot Moneyness_{i,t}^{-}$$
$$+\beta_4 \cdot Moneyness_{i,t}^{-} \cdot I^{HWM} + \gamma_1 \cdot Vix_t + \gamma_2 \cdot \Delta Vix_t + \gamma_3 \cdot \sigma_t^{Index_j} \cdot I^{j} + \gamma_4 \cdot \Delta\sigma_t^{Index_j} \cdot I^{j}$$
$$+\gamma_5 \cdot \sigma_{i,t-1} + \gamma_6 \cdot r_{i,t-1} + \gamma_7 \cdot I^{HWM} + \sum_k \delta_k YearDummy_k + \sum_l \lambda_l StyleDummy_l + \varepsilon_{i,t}$$

The dependent variable is the change in standard deviation of a hedge fund before and after it changes risk exposures. Control variables include Vix_t, the contemporary VIX Index average, ΔVix_t, the semi-annual change in it, $\sigma^{Index_j} \cdot I^{Index_j}$, the first six-month standard deviation of Credit Suisse Tremont Hedge Fund Indices of 10 risk strategies[1], $\Delta\sigma^{Index_j} \cdot I^{Index_j}$, the semi-annual change in it, and $\sigma_{i,1}$, the first six-month standard deviation of individual hedge funds.

These tests correct for heteroscedasticity in residual errors and diagnostic analyses do not detect mutlilinearity and serial correlation. *, ** and *** indicate a significance level of 10%, 5% and 1%, respectively. All regressions control for the fixed effects of years and hedge fund strategies.

The hurdle rate is set to 4% throughout this table.

[1] With the only exception of Fund of Hedge Funds, for which the TASS Fund of Funds Universe Average is used.

	Informed	Uninformed	Misinformed
Intercept	2.13	0.27	2.55
$Moneyness^{+}$	-0.13	0.46***	-0.05
$HWM*Moneyness^{+}$	0.09	-0.03	0.35***
$Moneyness^{-}$	-0.16	-0.19	-1.10***
$HWM*Moneyness^{-}$	-0.16	-0.14	0.43*
VIX_{t-1}	-0.05	0.00	-0.18
ΔVIX	0.96	0.33	0.81
σ_{-1}^{Index}	-0.02	0.36***	-0.26
$\Delta\ \sigma^{Index}$	0.11	0.21***	0.02
σ_{-1}	-0.79***	-0.57***	-0.70***
r_{-1}	-0.04***	-0.02	0.10***
HWM	-0.32	-0.21	-0.26
Year Dummies	Yes	Yes	Yes
Style Dummies	Yes	Yes	Yes
Observations	480	960	480
Adj. R^2	53.2%	35.6%	37.8%

*, ** and *** indicate a significance level of 10%, 5% and 1%, respectively

Table 3.6 Beta Risk Shifting Behavior of Three Groups of Hedge Fund Managers

This table reports the outputs of the following OLS regression model:

$$\Delta\sigma_{i,t,j}^{(beta)} = \alpha + \beta_1 \cdot Moneyness_{i,t}^{+} + \beta_2 \cdot Moneyness_{i,t}^{+} \cdot I^{HWM} + \beta_3 \cdot Moneyness_{i,t}^{-}$$
$$+\beta_4 \cdot Moneyness_{i,t}^{-} \cdot I^{HWM} + \gamma_1 \cdot Vix_t + \gamma_2 \cdot \Delta Vix_t + \gamma_3 \cdot \sigma_t^{Index_j} \cdot I^{j} + \gamma_4 \cdot \Delta\sigma_t^{Index_j} \cdot I^{j}$$
$$+\gamma_5 \cdot \sigma_{,i,t-1}^{(beta)} + \gamma_6 \cdot r_{i,t-1} + \gamma_7 \cdot I^{HWM} + \sum_k \delta_k YearDummy_k + \sum_l \lambda_l StyleDummy_l + \varepsilon_{i,t}$$

The dependent variable is $\Delta\sigma_{i,t,j}^{(beta)} = \sqrt{\frac{SSM_{i,t,j}}{k}} - \sqrt{\frac{SSM_{i,t-1,j}}{k}}$, in which SSM is the sum of squares about the mean from the three-factor model for hedge fund i that has the lowest BIC.. Control variables include Vix_t, the contemporary VIX Index average, ΔVix_t, the semi-annual change in it, $\sigma^{Index_j} \cdot I^{Index_j}$, the first six-month standard deviation of Credit Suisse Tremont Hedge Fund Indices of 10 risk strategies[2], $\Delta\sigma^{Index_j} \cdot I^{Index_j}$, the semi-annual change in it, and $\sigma_{i,1}$, the first six-month standard deviation of individual hedge funds.

These tests correct for heteroscedasticity in residual errors and diagnostic analyses do not detect mutlilinearity and serial correlation. *, ** and *** indicate a significance level of 10%, 5% and 1%, respectively. All regressions control for the fixed effects of years and hedge fund strategies.

The hurdle rate is set to 4% throughout this table.

[2] With the only exception of Fund of Hedge Funds, for which the TASS Fund of Funds Universe Average is used.

	Informed	Uninformed	Misinformed
Intercept	6.20	-1.12	8.05
$Moneyness^+$	-0.32	1.09***	-0.24
$HWM*Moneyness^+$	0.09	-0.10	0.86***
$Moneyness^-$	-0.57	-0.38	-2.79***
$HWM*Moneyness^-$	-0.33	-0.45	1.28
VIX_{t-1}	-0.23	0.14	-0.61
ΔVIX	2.41	0.26	2.60
σ_{-1}^{Index}	0.20	0.98***	-0.58
$\Delta\ \sigma^{Index}$	0.39	0.49***	0.06
σ_{-1}	-0.78***	-0.55***	-0.66***
r_{-1}	-0.08	-0.04	0.22
HWM	-0.95	-0.47	-0.73
Year Dummies	Yes	Yes	Yes
Style Dummies	Yes	Yes	Yes
Observations	384	1152	378
Adj. R^2	51.7%	36.4%	38.0%

*, ** and *** indicate a significance level of 10%, 5% and 1%, respectively

Table 3.7 Idiosyncratic Risk Shifting Behavior of Three Groups of Hedge Fund Managers

This table reports the outputs of the following OLS regression model:

$$\Delta\sigma_{i,t,j}^{(alpha)} = \alpha + \beta_1 \cdot Moneyness_{i,t}^{+} + \beta_2 \cdot Moneyness_{i,t}^{+} \cdot I^{HWM} + \beta_3 \cdot Moneyness_{i,t}^{-}$$
$$+\beta_4 \cdot Moneyness_{i,t}^{-} \cdot I^{HWM} + \gamma_1 \cdot Vix_t + \gamma_2 \cdot \Delta Vix_t + \gamma_3 \cdot \sigma_t^{Index_j} \cdot I^{j} + \gamma_4 \cdot \Delta\sigma_t^{Index_j} \cdot I^{j}$$
$$+\gamma_5 \cdot \sigma_{,i,t-1}^{(alpha)} + \gamma_6 \cdot r_{i,t-1} + \gamma_7 \cdot I^{HWM} + \sum_k \delta_k YearDummy_k + \sum_l \lambda_l StyleDummy_l + \varepsilon_{i,t}$$

The dependent variable is where $\Delta\sigma_{i,t,j}^{(alpha)} = \sqrt{\frac{SSE_{i,t,j}}{n-k-1}} - \sqrt{\frac{SSE_{i,t-1,j}}{n-k-1}}$, in which SSE is the sum of squared errors from the three-factor model for hedge fund i that has the lowest BIC. Control variables include Vix_t, the contemporary VIX Index average, ΔVix_t, the semi-annual change in it, $\sigma^{Index_j} \cdot I^{Index_j}$, the first six-month standard deviation of Credit Suisse Tremont Hedge Fund Indices of 10 risk strategies[3], $\Delta\sigma^{Index_j} \cdot I^{Index_j}$, the semi-annual change in it, and $\sigma_{i,1}$, the first six-month standard deviation of individual hedge funds.

These tests correct for heteroscedasticity in residual errors and diagnostic analyses do not detect mutlilinearity and serial correlation. *, ** and *** indicate a significance level of 10%, 5% and 1%, respectively. All regressions control for the fixed effects of years and hedge fund strategies.

The hurdle rate is set to 4% throughout this table.

[3] With the only exception of Fund of Hedge Funds, for which the TASS Fund of Funds Universe Average is used.

	Informed	Uninformed	Misinformed
Intercept	-1.06	-1.39	0.54
$Moneyness^{+}$	0.09**	0.12***	0.14***
$HWM*Moneyness^{+}$	0.07	-0.01	-0.05*
$Moneyness^{-}$	-0.25***	-0.16***	-0.50***
$HWM*Moneyness^{-}$	0.12**	0.05	0.32**
VIX_{t-1}	0.10	0.11	-0.02
ΔVIX	-0.21	-0.03	0.00
σ_{-1}^{Index}	0.11	0.18***	-0.01
$\Delta\ \sigma^{Index}$	0.03	0.03**	0.01
σ_{-1}	-0.72***	-0.71***	-0.82***
r_{-1}	0.01	0.00	0.01
HWM	-0.06	-0.04	-0.10*
Year Dummies	Yes	Yes	Yes
Style Dummies	Yes	Yes	Yes
Observations	480	960	480
Adj. R^2	52.0%	45.6%	49.8%

*, ** and *** indicate a significance level of 10%, 5% and 1%, respectively

Table 3.8 Total Risk Shifting Behavior of Three Groups of Hedge Fund Managers on Funds of Hedge Funds

This table reports the outputs of the following OLS regression model:

$$\Delta\sigma_{i,t}^{j} = \alpha + \beta_1 \cdot Moneyness_{i,t}^{+} + \beta_2 \cdot Moneyness_{i,t}^{+} \cdot I^{HWM} + \beta_3 \cdot Moneyness_{i,t}^{-}$$
$$+\beta_4 \cdot Moneyness_{i,t}^{-} \cdot I^{HWM} + \gamma_1 \cdot Vix_t + \gamma_2 \cdot \Delta Vix_t + \gamma_3 \cdot \sigma_t^{Index_j} \cdot I^{j} + \gamma_4 \cdot \Delta\sigma_t^{Index_j} \cdot I^{j}$$
$$+\gamma_5 \cdot \sigma_{i,t-1} + \gamma_6 \cdot r_{i,t-1} + \gamma_7 \cdot I^{HWM} + \sum_k \delta_k YearDummy_k + \varepsilon_{i,t}$$

The dependent variable is the change in standard deviation of a hedge fund before and after it changes risk exposures. Control variables include Vix_t, the contemporary VIX Index average, ΔVix_t, the semi-annual change in it, $\sigma^{Index_j} \cdot I^{Index_j}$, the first six-month standard deviation of TASS Fund of Funds Universe Average, $\Delta\sigma^{Index_j} \cdot I^{Index_j}$, the semi-annual change in it, and $\sigma_{i,1}$, the first six-month standard deviation of individual hedge funds.

These tests correct for heteroscedasticity in residual errors and diagnostic analyses do not detect mutlilinearity and serial correlation. *, ** and *** indicate a significance level of 10%, 5% and 1%, respectively. All regressions control for the fixed effects of years and hedge fund strategies.

The hurdle rate is set to 4% throughout this table.

	Informed	Uninformed	Misinformed
Intercept	-3.79	4.32	0.72
$Moneyness^{+}$	2.30	0.19	1.07**
$HWM*Moneyness^{+}$	-0.73	0.32	-0.54*
$Moneyness^{-}$	-0.18	-0.11	-0.60
$HWM*Moneyness^{-}$	-0.14	-0.70	-0.23
VIX_{t-1}	0.12	-1.32**	0.20
ΔVIX	-0.10	0.54***	0.03
σ_{-1}^{Index}	2.25	10.02**	-2.37
$\Delta\ \sigma^{Index}$	0.89	2.67	-0.24
σ_{-1}	-0.94***	-0.21***	-0.66***
r_{-1}	-0.16***	0.03	0.04
HWM	-0.35	-0.24	-0.35
Year Dummies	Yes	Yes	Yes
Style Dummies	No	No	No
Observations	115	232	116
Adj. R^2	79.9%	44.8%	64.8%

*, ** and *** indicate a significance level of 10%, 5% and 1%, respectively

Table 3.9 Comparison between Shifting and Non-Shifting Hedge Funds

Panel A reports the differences of shifting and non-shifting hedge funds on returns, monthly standard deviation, assets under management (AUM) and moneyness. Panel B compares the fund characteristics of the two groups. T-test significance for the comparisons is also provided.

Panel A Comparison of Mean Performance Variables			
	Shifting	Non-Shifting	(1)-(2)
Number of Funds	1572	4604	
Returns (%)	0.55	0.61	0.06
STD (%)	3.41	3.27	0.14
AUM (million dollars)	150.1	148.2	1.95
Moneyness	-0.007	-0.005	-0.003
Panel B Comparison of Mean Fund Characteristics			
	Shifting	Non-Shifting	(1)-(2)
Age (years)	6.65	6.45	0.19
IFee (%)	16.14	15.44	0.69
MFee (%)	1.45	1.47	-0.02
HighWaterMark (dummy)	0.59	0.59	-0.01
Personal Capital (dummy)	0.27	0.28	-0.02
Leverage (dummy)	0.49	0.55	-0.07

*, **, *** indicate a significance level of 10%, 5% and 1%, respectively.

Table 3.10 Robustness Check
Total Risk Shifting Behavior of Three Groups of Hedge Fund Managers

This table reports the outputs of the following OLS regression model:

$$\Delta\sigma_{i,t}^{j} = \alpha + \beta_1 \cdot Moneyness_{i,t}^{+} + \beta_2 \cdot Moneyness_{i,t}^{+} \cdot I^{HWM} + \beta_3 \cdot Moneyness_{i,t}^{-}$$
$$+\beta_4 \cdot Moneyness_{i,t}^{-} \cdot I^{HWM} + \gamma_1 \cdot Vix_t + \gamma_2 \cdot \Delta Vix_t + \gamma_3 \cdot \sigma_t^{Index_j} \cdot I^{j} + \gamma_4 \cdot \Delta\sigma_t^{Index_j} \cdot I^{j}$$
$$+\gamma_5 \cdot \sigma_{i,t-1} + \gamma_6 \cdot r_{i,t-1} + \gamma_7 \cdot I^{HWM} + \sum_k \delta_k YearDummy_k + \sum_l \lambda_l StyleDummy_l + \varepsilon_{i,t}$$

The dependent variable is the change in standard deviation of a hedge fund before and after it changes risk exposures. Control variables include Vix_t, the contemporary VIX Index average, ΔVix_t, the semi-annual change in it, $\sigma^{Index_j} \cdot I^{Index_j}$, the first six-month standard deviation of Credit Suisse Tremont Hedge Fund Indices of 10 risk strategies[4], $\Delta\sigma^{Index_j} \cdot I^{Index_j}$, the semi-annual change in it, and $\sigma_{i,1}$, the first six-month standard deviation of individual hedge funds.

All risk-shifting hedge fund managers are ranked according to their change in $\frac{r_i - r_f}{\sqrt{SSM / k}}$ before and after the risk-shifting and then divided into 5 groups. The top and bottom groups are identified as "Informed" and "Misinformed" managers. The rest three groups are "Uninformed" managers.

These tests correct for heteroscedasticity in residual errors and diagnostic analyses do not detect mutlilinearity and serial correlation. *, ** and *** indicate a significance level of 10%, 5% and 1%, respectively. All regressions control for the fixed effects of years and hedge fund strategies.

The hurdle rate is set to 4% throughout this table.

[4] With the only exception of Fund of Hedge Funds, for which the TASS Fund of Funds Universe Average is used.

	Informed	Uninformed	Misinformed
Intercept	3.33	0.32	2.53
$Moneyness^+$	-0.25	0.31***	0.04
$HWM*Moneyness^+$	0.19	0.10	0.24**
$Moneyness^-$	-0.21	-0.22	-1.44***
$HWM*Moneyness^-$	0.16	0.07	0.75*
VIX_{t-1}	1.36	0.03	-0.12
ΔVIX	-0.73	-0.08	0.81
σ_{-1}^{Index}	-0.01	0.23**	-0.05
$\Delta\ \sigma^{Index}$	0.21*	0.19***	0.02
σ_{-1}	-0.76***	-0.57***	-0.84***
r_{-1}	-0.03	-0.03*	-0.12***
HWM	-0.33	-0.25	-0.31
Year Dummies	Yes	Yes	Yes
Style Dummies	Yes	Yes	Yes
Observations	384	1152	378
Adj. R^2	53.9%	37.2%	40.9%

*, ** and *** indicate a significance level of 10%, 5% and 1%, respectively

Table 3.11 Robustness Check
Beta Risk Shifting Behavior of Three Groups of Hedge Fund Managers

This table reports the outputs of the following OLS regression model:

$$\Delta\sigma_{i,t,j}^{(beta)} = \alpha + \beta_1 \cdot Moneyness_{i,t}^{+} + \beta_2 \cdot Moneyness_{i,t}^{+} \cdot I^{HWM} + \beta_3 \cdot Moneyness_{i,t}^{-}$$
$$+\beta_4 \cdot Moneyness_{i,t}^{-} \cdot I^{HWM} + \gamma_1 \cdot Vix_t + \gamma_2 \cdot \Delta Vix_t + \gamma_3 \cdot \sigma_t^{Index_j} \cdot I^{j} + \gamma_4 \cdot \Delta\sigma_t^{Index_j} \cdot I^{j}$$
$$+\gamma_5 \cdot \sigma_{,i,t-1}^{(beta)} + \gamma_6 \cdot r_{i,t-1} + \gamma_7 \cdot I^{HWM} + \sum_k \delta_k YearDummy_k + \sum_l \lambda_l StyleDummy_l + \varepsilon_{i,t}$$

The dependent variable is $\Delta\sigma_{i,t,j}^{(beta)} = \sqrt{\frac{SSM_{i,t,j}}{k}} - \sqrt{\frac{SSM_{i,t-1,j}}{k}}$, in which SSM is the sum of squares about the mean from the three-factor model for hedge fund i that has the lowest BIC.. Control variables include $Vix_{t,}$ the contemporary VIX Index average, ΔVix_t, the semi-annual change in it, $\sigma^{Index_j} \cdot I^{Index_j}$, the first six-month standard deviation of Credit Suisse Tremont Hedge Fund Indices of 10 risk strategies[5], $\Delta\sigma^{Index_j} \cdot I^{Index_j}$, the semi-annual change in it, and $\sigma_{i,1}$, the first six-month standard deviation of individual hedge funds.

All risk-shifting hedge fund managers are ranked according to their change in $\frac{r_i - r_f}{\sqrt{SSM / k}}$ before and after the risk-shifting and then divided into 5 groups. The top and bottom groups are identified as “Informed” and “Misinformed” managers. The rest three groups are “Uninformed” managers.

These tests correct for heteroscedasticity in residual errors and diagnostic analyses do not detect mutlilinearity and serial correlation. *, ** and *** indicate a significance level of 10%, 5% and 1%, respectively. All regressions control for the fixed effects of years and hedge fund strategies.

The hurdle rate is set to 4% throughout this table.

[5] With the only exception of Fund of Hedge Funds, for which the TASS Fund of Funds Universe Average is used.

	Informed	Uninformed	Misinformed
Intercept	4.06	-0.25	6.93
$Moneyness^+$	-0.48	0.63	-0.06
$HWM*Moneyness^+$	0.29	0.21	0.61
$Moneyness^-$	-0.62	-0.97	-3.35***
$HWM*Moneyness^-$	0.40	0.18	1.81***
VIX_{t-1}	0.23	0.14	-0.38
ΔVIX	-1.78	-0.51	2.69
σ_{-1}^{Index}	0.25	0.66*	-1.17
$\Delta\ \sigma^{Index}$	0.62	0.45***	0.04
σ_{-1}	-0.77***	-0.54***	-0.77***
r_{-1}	-0.06	-0.05	-0.26***
HWM	-0.87	-0.65	-0.66
Year Dummies	Yes	Yes	Yes
Style Dummies	Yes	Yes	Yes
Observations	480	960	480
Adj. R^2	50.2%	35.3%	36.8%

*, ** and *** indicate a significance level of 10%, 5% and 1%, respectively

Table 3.12 Robustness Check
Idiosyncratic Risk Shifting Behavior of Three Groups of Hedge Fund Managers

This table reports the outputs of the following OLS regression model:

$$\Delta\sigma_{i,t,j}^{(alpha)} = \alpha + \beta_1 \cdot Moneyness_{i,t}^{+} + \beta_2 \cdot Moneyness_{i,t}^{+} \cdot I^{HWM} + \beta_3 \cdot Moneyness_{i,t}^{-}$$
$$+\beta_4 \cdot Moneyness_{i,t}^{-} \cdot I^{HWM} + \gamma_1 \cdot Vix_t + \gamma_2 \cdot \Delta Vix_t + \gamma_3 \cdot \sigma_t^{Index_j} \cdot I^{j} + \gamma_4 \cdot \Delta\sigma_t^{Index_j} \cdot I^{j}$$
$$+\gamma_5 \cdot \sigma_{,i,t-1}^{(alpha)} + \gamma_6 \cdot r_{i,t-1} + \gamma_7 \cdot I^{HWM} + \sum_k \delta_k YearDummy_k + \sum_l \lambda_l StyleDummy_l + \varepsilon_{i,t}$$

The dependent variable is where $\Delta\sigma_{i,t,j}^{(alpha)} = \sqrt{\frac{SSE_{i,t,j}}{n-k-1}} - \sqrt{\frac{SSE_{i,t-1,j}}{n-k-1}}$, in which SSE is the sum of squared errors from the three-factor model for hedge fund i that has the lowest BIC. Control variables include Vix_t, the contemporary VIX Index average, ΔVix_t, the semi-annual change in it, $\sigma^{Index_j} \cdot I^{Index_j}$, the first six-month standard deviation of Credit Suisse Tremont Hedge Fund Indices of 10 risk strategies[6], $\Delta\sigma^{Index_j} \cdot I^{Index_j}$, the semi-annual change in it, and $\sigma_{i,1}$, the first six-month standard deviation of individual hedge funds.

All risk-shifting hedge fund managers are ranked according to their change in $\frac{r_i - r_f}{\sqrt{SSM / k}}$ before and after the risk-shifting and then divided into 5 groups. The top and bottom groups are identified as "Informed" and "Misinformed" managers. The rest three groups are "Uninformed" managers.

These tests correct for heteroscedasticity in residual errors and diagnostic analyses do not detect mutlilinearity and serial correlation. *, ** and *** indicate a significance level of 10%, 5% and 1%, respectively. All regressions control for the fixed effects of years and hedge fund strategies.

The hurdle rate is set to 4% throughout this table.

[6] With the only exception of Fund of Hedge Funds, for which the TASS Fund of Funds Universe Average is used.

	Informed	Uninformed	Misinformed
Intercept	-0.43	-1.04	0.39
$Moneyness^{+}$	0.05	0.13***	0.11***
$HWM*Moneyness^{+}$	0.13**	-0.04	-0.05
$Moneyness^{-}$	-0.15***	-0.25***	-0.36***
$HWM*Moneyness^{-}$	0.05*	0.11***	0.19*
VIX_{t-1}	0.04	0.09	-0.04
ΔVIX	-0.03	0.00	0.52
σ_{-1}^{Index}	0.08	0.15***	-0.07
$\Delta\ \sigma^{Index}$	0.01	0.03**	0.00
σ_{-1}	-0.76***	-0.74***	-0.71***
r_{-1}	0.00	0.00	0.00
HWM	-0.04	-0.00	-0.08
Year Dummies	Yes	Yes	Yes
Style Dummies	Yes	Yes	Yes
Observations	384	1152	378
Adj. R^2	58.0%	47.6%	42.3%

*, ** and *** indicate a significance level of 10%, 5% and 1%, respectively

Figure 3.1 Risk style distribution of Shifting Funds vs. All Funds

Out of a total of 6176 hedge funds in data there are 1572 hedge funds that change risk exposures at 10% significance level in at least one calendar year during 1994 and 2008. The graph compares the percentage of each risk style for both shifting funds and the whole hedge fund family.

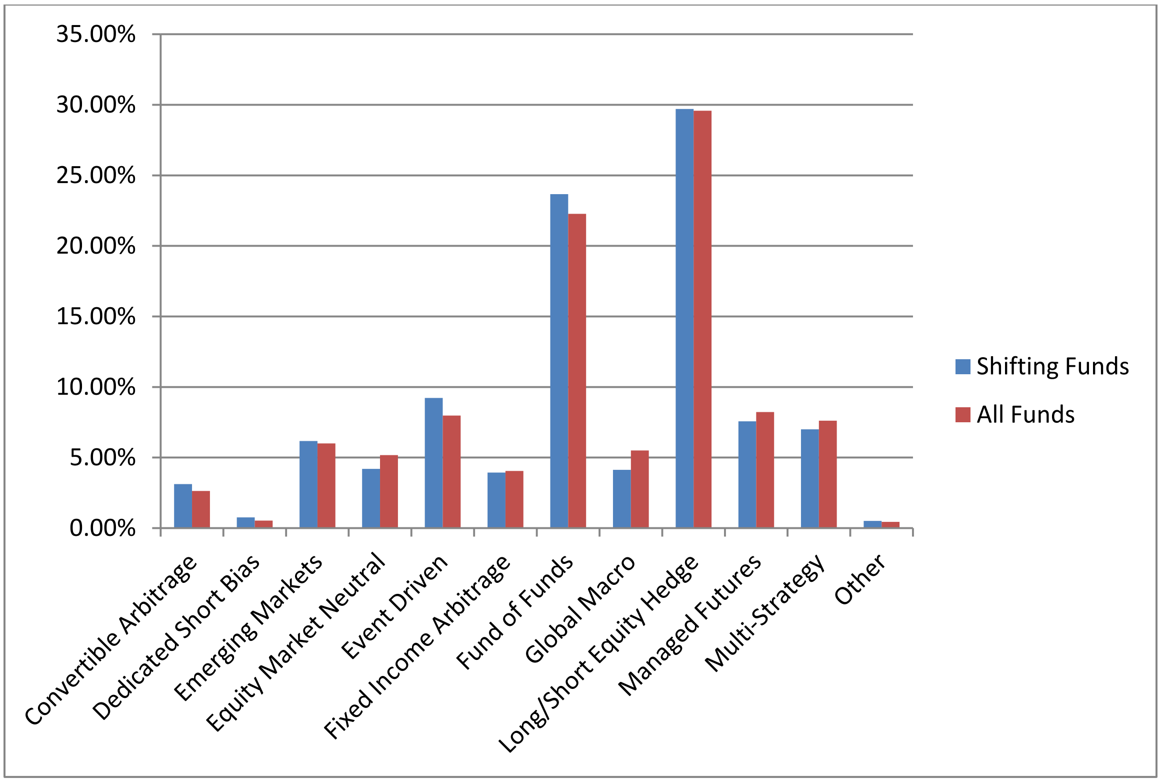
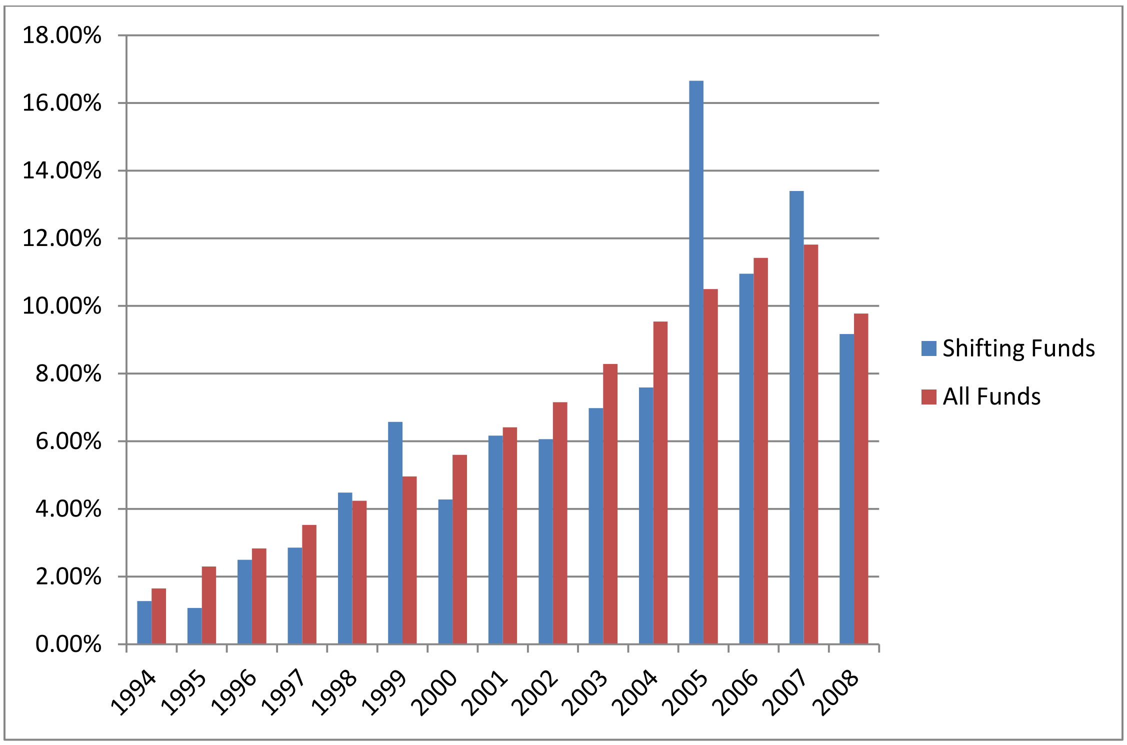


Figure 3.2 Year distribution of Shifting Funds vs. All Funds

Out of a total of 6176 hedge funds in data there are 1572 hedge funds that change risk exposures at 10% significance level in at least one calendar year during 1994 and 2008. The graph compares the percentage of the calendar year during which changes in risk exposures take place for both shifting funds and the whole hedge fund family.



APPENDIX A

MATH DERIVATIONS IN CHAPTER 1

A.1 Optimal Effort Level in Model I

Following we solve the investor's optimization problem in (1.5) for the optimal effort level e^* she wants to induce from the manager, given the fixed fee contract in (1.8). Mathematically,

$$\max_{e} E[G] = \int g(Ir - f(\bar{u}_0 + c(e)))dF(r|e) \tag{A-1}$$

The FOC

$$\begin{aligned} \frac{dE[G]}{de} &= \int g(Ir - f(\bar{u}_0 + c(e)))f_e(r|e)dr \\ &+ \int g'(Ir - f(\bar{u}_0 + c(e))) \cdot -f'(\bar{u}_0 + c(e))c'(e)f(r|e)dr \end{aligned} \tag{A-2}$$

Given the investor's CARA utility function in (1.13), the FOC becomes,

$$
\begin{aligned}
\frac{dE[G]}{de} &= \int -\exp(-\lambda_p(Ir - f(\bar{u}_0 + c(e))))\frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(r-x(e))^2}{2\sigma^2})\cdot\frac{r-x(e)}{\sigma^2}\cdot x'(e)dr \\
&+ \int \lambda_p \exp(-\lambda_p(Ir - f(\bar{u}_0 + c(e))))\cdot -f'c'\frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(r-x(e))^2}{2\sigma^2})dr \\
&= 0 \qquad \text{(A-3)}
\end{aligned}
$$

Substituting $r - x(e)$ by t in each integral, we have,

$$
\begin{aligned}
\frac{dE[G]}{de} &= x'\exp(-\lambda_p f(\bar{u}_0 + c(e)))\int -\exp(-\lambda_p I(t+x)\frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{t^2}{2\sigma^2})\cdot\frac{t}{\sigma^2}\cdot x'(e)dt \\
&- \lambda_p f'c'\exp(-\lambda_p f(\bar{u}_0 + c(e)))\int \lambda_p \exp(-\lambda_p I(t+x))\frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{t^2}{2\sigma^2})dt \\
&= 0 \qquad \text{(A-4)}
\end{aligned}
$$

Simplify and we have,

$$
\begin{aligned}
\frac{dE[G]}{de} &= \lambda_p I \exp(-\lambda_p I x + \frac{\lambda_p^2 I^2 \sigma^2}{2})x'(e) \\
&- -\lambda_p f'c'(e)\exp(-\lambda_p I x + \frac{\lambda_p^2 I^2 \sigma^2}{2}) \\
&= 0 \qquad \text{(A-5)}
\end{aligned}
$$

Substitute $f'(x)$ by $\frac{1}{\lambda_a x}$, given the manager's CARA utility function in (1.14),

$$
\begin{aligned}
c'(e) &= \frac{I}{f'}x'(e) \\
&= \lambda_a I(\bar{u}_0 + c(e))x'(e) \qquad \text{(A-6)}
\end{aligned}
$$

A.2 Optimal Effort Level in Model II

Following we solve the investor's optimization problem in (2.7) for the optimal effort level $e^{*}*$ she wants to induce from the manager, given the fixed fee contract in (1.9).

The FOC

$$
\begin{aligned}
\frac{\partial E[U]}{\partial e} &= \int u(\alpha I+\beta I r) f_e(r|e)dr - c'(e) \\
&= \int -\exp(-\lambda_a(\alpha I+\beta I r))\frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(r-x(e))^2}{2\sigma^2})\cdot\frac{r-x(e)}{\sigma^2}\cdot x'(e)dr \\
&= 0 \qquad \text{(A-7)}
\end{aligned}
$$

Substituting $r-x(e)$ by t, we have,

$$
\begin{aligned}
\frac{\partial E[U]}{\partial e} &= \exp(-\lambda_a\alpha I-\lambda_a\beta I x)\int -\frac{1}{\sqrt{2\pi}\sigma}\exp(-\lambda_a\beta I t-\frac{t^2}{2\sigma^2})\cdot\frac{t}{\sigma^2}\cdot x'(e)dt \\
&= 0 \qquad \text{(A-8)}
\end{aligned}
$$

Simplify and we have,

$$
c'(e) = \lambda_a\beta I\exp(-\lambda_a\alpha I-\lambda_a\beta I x(e)+\frac{\lambda_a^2\beta^2 I^2\sigma^2}{2})x'(e) \qquad \text{(A-9)}
$$

A.3 The Second Term in (1.22)

When $r<0$, $u(\alpha I)-u(\alpha I+\beta I r)>0$. Also, when $r<0$, $r-x(e)<0$, and therefore $f_e(r|e)=\frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(r-x)^2}{2\sigma^2})x'(e)<0$, since $x'(e)>0$ for all e by assumption.

Since the integrand is everywhere positive on $(-\infty,0]$, the integral,

$$\int_{-\infty}^{0}[u(\alpha I)-u(\alpha I+\beta Ir)]f_e(r|e^{***})dr<0 \tag{A-10}$$

A.4 The MP in (1.27) Larger than in (1.22)

Rewrite (1.27)

$$\begin{aligned}
c'(e^k) &= \int_{-\infty}^{0}u(\alpha I)f_e(r|e^k)dr+\int_{0}^{\infty}u(\alpha I+\beta Ir)f_e(r|e^k))dr \\
&+ \int_{-\infty}^{0}(u((1-k)\alpha I+kIr)-u(\alpha I))f_e(r|e^k)dr \\
&+ \int_{0}^{\infty}(u((1-k)(\alpha I+\beta Ir)+kIr)-u(\alpha I+\beta Ir))f_e(r|e^k)dr
\end{aligned} \tag{A-11}$$

Note that the first two terms are the MC in (1.22), we then need to prove the sum of the last two terms is positive. Perform Tylor series expansion on the integrand in the third term (denoted by T) about around αI, assuming k is small,

$$\begin{aligned}
T &= \int_{-\infty}^{0}(u((1-k)\alpha I+kIr)-u(\alpha I))f_e(r|e^k)dr \\
&\approx \int_{-\infty}^{0}(u(\alpha I)+u'(\alpha I)k(Ir-\alpha I)-u(\alpha I))f_e(r|e^k)dr \\
&= \int_{-\infty}^{0}u'(\alpha I)k(Ir-\alpha I)\frac{1}{\sqrt{2\pi}\sigma}\exp(-\frac{(h-x(e))^2}{2\sigma^2})\cdot\frac{h-x(e)}{\sigma^2}\cdot x'(e)dr
\end{aligned} \tag{A-12}$$

Denote the fourth term by S and perform Tylor series expansion on the integrand around $\alpha I+\beta Ir$. Similarly,

$$S = \int_0^{\infty} u'(\alpha I + \beta I r) k(Ir - \beta I r - \alpha I) \frac{1}{\sqrt{2\pi}\sigma} \exp(-\frac{(h - x(e))^2}{2\sigma^2}) \cdot \frac{h - x(e)}{\sigma^2} \cdot x'(e) dr \tag{A-13}$$

Let α=0, then,

$$T|_{\alpha=0} = \int_{-\infty}^{0} u'(0) k I r \frac{1}{\sqrt{2\pi}\sigma} \exp(-\frac{(h - x(e))^2}{2\sigma^2}) \cdot \frac{h - x(e)}{\sigma^2} \cdot x'(e) dr > 0 \tag{A-14}$$

$$S|_{\alpha=0} = \int_0^{\infty} u'(\beta I r) k(Ir(1 - \beta)) \frac{1}{\sqrt{2\pi}\sigma} \exp(-\frac{(h - x(e))^2}{2\sigma^2}) \cdot \frac{h - x(e)}{\sigma^2} \cdot x'(e) dr > 0 \tag{A-15}$$

By continuity, $T > 0$ and $S > 0$. Therefore, the MP in (1.27) is larger than that in (1.22).

A.5 The shape of $A(h, e)$

$$\begin{aligned} \frac{\partial A(h,e)}{\partial h} &= [u(\alpha I) - u(\alpha I + \beta I r)] f_e(r|e) \\ &= [u(\alpha I) - u(\alpha I + \beta I r)] \frac{1}{\sqrt{2\pi}\sigma} \exp(-\frac{(h - x(e))^2}{2\sigma^2}) \cdot \frac{h - x(e)}{\sigma^2} \cdot x'(e) \end{aligned} \tag{A-16}$$

Since $u(x)$ is increasing in x, $u(\alpha I) - u(\alpha I + \beta I r) < 0$. Therefore, the sign of $\frac{\partial A(h,e)}{\partial h}$ conversely depends on the sign of $h - x(e)$.

A.6 $A(h,e) < 0$

we see in (1.34) that $A(h,e)$ decreases in h when $h > x(e)$. Now consider that $x(e) = 0$. Since $A(h,e) = 0$ and $A(h,e)$ decreases in h when $h > x(e) = 0$, $A(h,e)$ is thus negative for all $h > 0$. By the continuity of $A(h,e)$ in e, there exists an $h_0 > 0$ and $e_0 > 0$, such that when $h > h_0$ and $e < e_0$, $A(h,e) < 0$. That is, if $A(h,e) < 0$ is negative on a point of x, then it must be negative on a continuous interval around x.

APPENDIX B

CALCULATION OF HWM AND GROSS RETURNS

Solving for the HWM and gross return series of hedge funds.

(1) Lipper TASS database reports a variable called '*InitialNAV*'[1] and we define that for hedge fund i,

$$NAV_{i,0}^{*} = InitialNAV \tag{B-1}$$

(2) The reported NAVs are based on net returns.

$$NAV_{i,t} = NAV_{i,t-1} \times (1 + r_{i,t}^{Net}) \tag{B-2}$$

(3) The HWM is updated monthly.

$$NAV_{i,t}^{*} = Max\{NAV_{i,t}, NAV_{i,t-1}^{*}\} \tag{B-3}$$

(4) Management fees are paid and incentive fees are accrued also on a monthly basis.[2]

$$MgtFee_{i,t} = NAV_{i,t} \times \frac{MgtFee\%}{1 - MgtFee\%} \tag{B-4}$$

[1] If the value is missing, we use the first reported NAV instead.

[2] Assuming that the reported NAVs are net of fees.

$$AccruedIncentFee_{i,t} = Max\{NAV_{i,t} - NAV^{*}_{i,t-1}, 0\} \times \frac{IncentFee\%}{1 - IncentFee\%} \tag{B-5}$$

(5) The calculation of gross returns takes into account management fees and accrued incentive fees.

$$r^{Gross}_{i,t} = \frac{(NAV_{i,t} + AccruedIncentFee_{i,t}) - (NAV_{i,t-1} + AccruedIncentFee_{i,t-1}) + MgtFee_{i,t}}{NAV_{i,t-1} + AccruedIncentFee_{i,t-1}} \tag{B-6}$$

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